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FRACTURES OF THE NECK OF THE FEMUR[1]

W. RUSSELL MACAUSLAND, M.D., ANDREW R. MACAUSLAND, M.D., AND HAROLD G. LEE, M.D., BOSTON
From the MacAusland Orthopedic Clinic

THE efficacy of the Whitman abduction method in treating fractures of the neck of the femur has been recognized by surgeons throughout the world, and the procedure, for the most part, generally accepted as the standardized form of treatment. When operators hesitate to adopt this method, the explanation lies either in their desire to substitute a method that will eliminate the long, tedious convalescence necessitated by the Whitman treatment, or in the fact that they are perplexed as to the actual effectiveness of the treatment in large series of cases. On the whole, few reliable statistics have been published on the results of this method. There is not only a lack of uniformity in the tabulation of outcomes, but also a great deal of inaccuracy. As a result, the percentages of satisfactory and unsatisfactory outcomes vary considerably, and the lack of accurate data reflects unfavorably upon the method of treatment. As yet, the methods devised with a view to shortening the convalescent period have been used in too few cases to permit us to draw conclusions as to their value. In the light of our present experience, the limited application of these newer forms of treatment, and particularly of operative methods, should be appreciated.

It is with the twofold intention of reporting an accurately detailed account of our experience with the Whitman method, and of defining the proper place of operative interference in treatment at the present time, that this article is presented. We consider that our results from the use of the Whitman method have been favorable, and we shall continue to carry out the established principles of treatment that have thus far proved of value to us.

DESCRIPTION OF CASE SERIES

Two hundred and fifty cases of fractures of the femoral neck were treated at our clinic within a period of 23 years, that is, from 1908 to December, 1931. The latter is the final date used for the basis of an end-result. All cases in our report are listed consecutively as they came to our clinic for treatment. Of this number, 159 cases were fresh fractures of the medial and upper neck; 56 were fresh fractures of the trochanteric region, in which were included fractures of the base of the neck; and 35 were ununited fractures. The Whitman method of reduction was used in practically all the fresh fractures, and operative measures were reserved for cases of non-union.

FRESH FRACTURES OF THE MEDIAL AND UPPER NECK

Etiology. The usual history of a fall, often due to tripping over a rug, was reported by the great majority of our patients. There was only one case of a pathological fracture in our series, the origin of which was traced to carcinoma of the breast.

[1]We desire to express our sincere appreciation to the many physicians who have helped us in compiling the case data and the roentgenographic material for this paper.

Diagnosis. In the average case the diagnosis presents no difficulty, the syndrome being well known, but in the exceptional case in which the patient is not extremely incapacitated, and may even walk without assistance, the fracture may be overlooked. Six of our patients walked for periods varying from 2 weeks to 2 months following the fracture. In 2 of these cases an incorrect diagnosis had been made, with the result that the advantage of early treatment was lost. Attention is called to these cases in which the power of locomotion persists, in order to emphasize the importance of noting carefully all symptoms and signs following a fall in the case of an elderly individual, and to stress the importance of taking roentgenographic views from several angles. Recently, Leonard and George made a valuable contribution to the roentgenographic study of these fractures when they discovered that it is possible to obtain vertical views of the femoral neck with a curved film holder (Fig. 1).

Pathology. An understanding of the pathology of this fracture, especially in its relation to treatment, is essential to satisfactory handling of the lesion.

Certain bone changes take place that must be taken into consideration in treating these fractures. The first of these is a generalized atrophy, a variation that is observed in any fracture. It is a well known fact that a normal bone that has been put at rest for a week undergoes a loss of lime salts sufficient to show in a roentgenogram. In a fracture of the hip, therefore, it is expected that atrophy will be observed. Whether the atrophy in the proximal fragment may be explained by disuse alone is a subject of discussion, but it is our opinion that this factor in itself may be responsible. The head of the femur immediately following the fracture is placed practically out of commission; muscle pull and slight motion do not produce even a small proportion of the strain to which it has been accustomed. The atrophy, therefore, may become extremely severe, and surgeons who have intervened in old cases of non-union have observed that the structure of the head is practically lost.

In addition to the generalized atrophy, a certain amount of absorption of bone takes place at the site of the fracture. This absorption is not peculiar to fractures of the neck of the femur, for in fractures of any long bone there is a definite tendency toward absorption of both bone-ends during the first stage of healing. In an ordinary transverse fracture of the femoral shaft, which heals normally, this absorption of bone may amount to a quarter of an inch. It is not surprising, then, to find absorption amounting to one-half or three-quarters of an inch in fractures of the neck, even when healing takes place; and if union is considerably delayed or non-union persists, the femoral neck may entirely disappear. The causes of absorption may be normal, incidental to the re-adjustment of circulation and the beginning of bone repair; or abnormal, due to excessive use or strain at the site of non-union, where the bone-ends are markedly atrophied and unable to stand such strain.

The impacted fracture. For many years there has existed a common misconception of the pathology of certain fractures of the femoral neck. A particular type of fracture has been considered to be "impacted," the term connoting a certain stability and voluntary control of the limb as the result of the penetration of one fragment into another. The development of this theory of impaction is explained to some extent by inaccurate interpretation of the roentgenogram, which always shows a foreshortening of the femoral neck due to overlapping of the fragments. As a matter of fact, true impaction of the fragments in these fractures does not occur. The fracture designated as impacted is either one of the incomplete variety, or a complete fracture in which, because of the good preservation of the capsule and periosteum, only slight deformity is present, and some power of movement is retained. It is possible, too, that in some cases a slight interjunctional splintering is present which, by causing the motion to be more limited when the muscles tighten to protect the affected area during examination, prevents the determination of a complete fracture line. The fallacy of this idea of impaction is apparent when we consider that in these fractures the posterior or the weaker part of the neck is crumpled, while the

front and stronger part, being only cracked, merely buckles, but is not displaced. The fallacy seems all the more definite when, with the lapse of 2 or 3 weeks, during the period of observation, the fracture line is seen to become complete, and the fragments loosen.

The early teaching was to leave these fractures alone, or to use protection only, for fear that disturbing the fragments would promote non-union. As a rule, these fractures when treated by rest alone do not heal, and in the course of a few weeks when body-weight is borne, a slight twist or turn results in the breaking-up of the temporary stability. At this stage, however, the advantage afforded by early manipulation has been lost. In the infrequent case in which union takes place, deformity in the form of shortening, adduction, and outward rotation of the leg develops. Of particular significance is the disturbed relation between the femoral neck and shaft, producing a coxa vara. In time, the interference with the function of the joint leads to the development of arthritic changes with their accompanying pain and limitation of motion.

The so called impacted fractures practically always call for the same treatment as other fractures of the neck of the femur. Under proper care any displacement of the fragments is prevented. It is only when there is no displacement, or in the rare case of coxa valga, or when the patient is extremely elderly, that disturbance of such a fracture is unwarranted.

Union. Bone-repair in the intracapsular type of fracture takes place almost entirely by internal callus formation. Contrary to the view held by many observers, it is our opinion that wherever union occurs there is some external callus formation, although it may be difficult to demonstrate it in the roentgen film. This is so because its area is not represented vividly or because the callus is too slight in amount to be demonstrated. Some indication of this external callus is seen when cases are treated operatively.

The formation of bone in these fractures is slow, due undoubtedly to the fact that nourishment and protection of new bone come chiefly from the distal fragment in which the circulation remains undisturbed. Just what

TABLE I.—GENERAL FEATURES—159 CASES

	Cases	Per cent
Males	34	21
Females	125	79
Ages		
20–29	1	
30–39	4	
40–49	9	
50–59	20	
60–69	43	
70–79	35	70
80–89	23	
90+	3	
Unrecorded	12	
	159	
Hip involved		
Left	78	
Right	68	
Unrecorded	13	
	159	

part the proximal fragment plays in osteogenesis is much disputed. There are surgeons who believe that the head is not viable from the moment a fracture occurs, while others believe that the fragment is nourished through the teres ligamentum. In this connection it is interesting to study the findings in anatomical dissections of ununited fractures of the femoral neck. The proximal fragment, as stated, shows marked atrophy of the cancellous structure, cortex, and cartilage covering the capitulum. Over the end of the fragment is a heavy fibrous covering, or pannus, which must be removed in order to observe the interior structure. To the outer rim of this pannus are usually attached the remains of the capsule, as well as a new fibrous tissue formation that runs out and extends to the rim of the acetabulum. This tissue is a new formation and is not found in the normal hip. We believe that it is through this tissue that the blood supply comes to the head. Just when and how long it takes this fibrous sheath to form we have not been able to determine. In view of these findings, it is our opinion that the femoral head is always living.

Due to the slowness of repair, at least 6 months is required to obtain union in the typical case. Roentgenograms should be taken at regular intervals, and we desire to stress particularly the importance of interpreting them correctly. It is possible to note the progress of union about the second month;

the shorter fragment shows considerable absorption, and the edge of the bone shows a penciling from atrophy. Definite sharpening of the corners will be noted, causing the fractured site to have the same appearance that a sequestrum does in an osteomyelitis. The texture of this fragment contrasts with that of the shaft fragment in which there is considerable atrophy, but in which the edge of the bone shows only lightly without any heavy penciling. By the third or fourth month new circulation has developed, a pons has grown across from the edge of the acetabulum, and new bone cells are present throughout the capital fragment.

A great deal of care must be taken not to misinterpret the radiograms at the end of the second or third month. The marked absorption that is usually seen, with a thickening of bone on either side of a lozenge-shaped area may be incorrectly interpreted as an ununited fracture. At this stage of healing, such an appearance is of no importance, provided the fragments are still in good position. In fact, it is a stage of union, and if one persists in immobilization, the thickening begins to be absorbed, and as the shell on either side absorbs, the center begins to fill in. This process is seen, as a rule, only in fractures that are practically intrajoint fractures, although occasionally a somewhat similar picture is seen in injuries to the joint itself, or in an improperly treated fracture of a long bone.

TREATMENT

The many difficulties—mechanical, nutritive, and physical—that the surgeon encounters in treating these fractures are well known. In only a comparatively few cases are these obstacles so great that treatment is to be regarded as futile, and the majority of these fractures, when treated on the same principles as other fractures, are amenable to proper care.

In general, the fundamental principles governing the treatment of these fractures are as follows:

1. Early care, including the treatment of shock and the prevention of the development of pneumonia and cardiac disturbance.
2. Accurate reduction of the fragments.
3. Maintenance of the fragments in good position for a sufficient period to ensure union.
4. Careful after-care.
5. The institution of function to prevent excessive atrophy of the proximal fragment.
6. Careful observation of the process of healing.

Reduction, when possible, should be made immediately after the injury. After the lapse of more than a week's time, reposition of the fragments by a conservative form of treatment is more difficult, and may even be impossible because of the presence of blood clots and fibrous tissue.

There are in use at the present time three methods of reduction: the Whitman abduction method; various forms of traction; and operative methods. The selection of the method depends upon the age of the patient, the presence of complications, the type of fracture, and the experience of the surgeon in a particular line of treatment.

The Whitman method. Of these methods the Whitman (14) procedure has been the most widely used, and surgeons who have had the most experience in this field are of the opinion that it is still the method of choice for the majority of cases. The technique of the procedure is well known. The manipulation is carried out with the patient narcotized. As the anæsthetic, ether may be used with safety, provided the patient is cared for properly. In our entire series of 250 cases, there were only 11 cases of pneumonia during the first 3 weeks of treatment, and in only 5 of them is there a possibility that ether was the direct cause of the complication. In a number of elderly patients we have successfully used large doses of morphine for a narcotic. It is administered as follows: Two hours before reduction, the patient is given 3 grains of luminal, and 1 hour later, 1/6 grain of morphine sulphate and 1/200 grain of hyoscine hydrobromide are injected subcutaneously. The patients have no recollection of the manipulation and remain narcotized for about 10 hours after the reduction.

The care of the patient immediately following the application of the plaster spica is of prime importance, as hypostatic congestion develops easily in these cases. A firm mattress

with a fracture board beneath it should be used. When the patient is elderly, it is well to elevate the head, sides, and foot of the bed alternately for 2 hour periods. At least twice a day the patient should be turned in bed, so that he lies for 20 minutes at a time, first on his face and then on his side. This turning of the patient and elevating of the bed should be continued until the patient is able to sit in a wheel-chair once a day.

Of vital importance, too, is the after-care instituted to stimulate the circulation in order to promote early union and keep the musculature in tone. By various arrangements of bars and pulleys the patient can move himself about in bed. Twenty-four hours after reduction he should sit on the edge of the bed, and by the third day, he should be out of bed, sitting in a wheel-chair, and if possible, walking with crutches. Early weight-bearing not only stimulates the circulation, but also keeps up the patient's sense of equilibrium and helps to make him confident that he will be able to walk again. While the limb is in the spica, muscle contractions should be carried out at varying intervals throughout the day, 100 times at each session.

At the expiration of 4 or 5 months, it is often advisable, and particularly so in elderly patients, to insert a joint in the plaster spica at the knee. This arrangement allows a little motion at the knee joint, and the patient is encouraged to use his limb. In some cases it is possible to remove the portion of the spica from the midcalf to the toes at the end of the fourth month, but care must then be taken to control the consequent swelling of the foot by applying a firm flannel bandage. After 5 months the anterior half of the spica may be removed temporarily to allow baking and massage. At this time a moderate amount of motion may be allowed the hip joint, and mild weight-bearing on the toes is of advantage.

The limb should be kept immobilized for at least 6 months. The modern trend to cut short the period of immobilization in treating fractures near joints, and to institute early active motion to incite bony growth, is to be questioned. In our clinic we have tried both weight-bearing and non-weight-bearing methods, and from our experience we conclude that the indiscriminate use of early motion of joints proximate to fractures is to be avoided. The rational view is to wait for healing and to put no strain on the site of fracture, until the surfaces have united sufficiently to bear that strain.

Upon the final removal of the plaster spica, baking, deep massage, and gentle passive exercises are carried out. Considerable muscle re-education is necessary to effect a complete return of strength. When the roentgenogram shows evidence of increased union, and the patient appears to be sufficiently active and suffering no pain, full weight-bearing may be allowed. If necessary, a caliper may be worn to minimize the amount of weight-bearing for a time.

Traction methods. Traction methods, until recently, have been used only when the patient could not tolerate the plaster spica or was suffering from shock or complications. The limited use of these methods in the past has been due to the difficulties presented in their application and the maintenance of the position of the fragments. With the introduction of newer forms of skeletal traction, such as the Jones traction splint and the skeletal traction splint devised by Anderson, which are more available and simple and accurate in application, these methods are being used more widely, and we shall without doubt see further development of this form of treatment. Within the past year, we have used these newer traction methods in a large series of cases, and a report of the end-results will be published when sufficient time has elapsed to permit judging the outcomes.

At the time of this paper we are able to report the end-results in only 4 cases in which traction was used. The Boehler method was used in all 4 cases. One patient, aged 72 years at the time of the fracture, is now (1 year after reduction) walking without a limp and has firm bony union. The second patient, aged 63 years, who was an emaciated individual with an old pulmonary tuberculosis, walks without a limp (Fig. 2). The third patient, aged 85 years, had had an interstitial nephritis at the time of the fracture, and obtained a poor result. The fourth patient died of pneumonia 9 months after the fracture.

Operative treatment of fresh fractures. It is our opinion that at the present time operative measures should be reserved for a selected group of cases. Whether this group should include a larger number of cases than are now recognized as operable, that is whether our treatment tends to be too conservative, yet remains to be determined. We do not agree, however, with the group of operators who, stressing in particular the desirability of shortening the long convalescent period, believe that every fracture of the femoral neck is operable from the moment that it takes place. To be sure, it is difficult to combat such a view, for we are all anxious to restore function within as short a period as possible. Experience, on the other hand, teaches us to doubt the reasonableness of such an opinion, and further statistics are needed to substantiate it.

Provided no contra-indications as to age and physical condition are present, operation is justified in the following instances: when alinement of the fractured surfaces cannot be obtained by the Whitman method; when the apposition of the fragments is considered unsatisfactory; and when the patient cannot tolerate the Whitman method.

Only four operative methods have been recommended for the treatment of fresh fractures: the Hey-Groves "proximal pegging" operation, the Albee graft method, the Jones (8) graft method, and the Smith-Petersen fixation. At the present time, we are considering whether operative reduction of the fracture may not have a place in the treatment of selected cases under 60 years of age. Certainly in many fractures at other sites in which conservative manipulation fails to result in accurate reduction, simple exploration with anatomical reposition gives perfect results.

Of the four methods in use, the most satisfactory, in our opinion, is the bone-graft method, for such an operative procedure not only provides for fixation of the fragments, but it also introduces a callus-forming substance into the fractured area. The Jones method, which was introduced only within the past year, seems to have several advantages over the Albee procedure. Dr. Jones (9) has not yet published statistics of his end-results, as he is waiting for a period of at least 18 months to elapse from the time of operation before issuing a report (Fig. 3).

The Smith-Petersen method has been used more extensively than any other operative procedure in the treatment of fresh fractures. This method has not been accepted favorably by a number of surgeons because it involves the use of a foreign substance. We are among those operators who are opposed to the use of any foreign body in the treatment of a fracture, since it has been our experience that when metal is in contact with bone, liquefaction or even necrosis and infection develops, with its customary inhibitory effect upon the formation of callus. Such a liquefactive process develops in the presence of any metal substance, regardless of its shape or size.

Our experience with operative measures in fresh fractures has been limited to 2 cases. In 1, in which the fracture was not recognized for 6 weeks, the tibial graft method of Albee was used with success. In the other case, a Whitman reconstruction operation was performed 2 weeks after the fracture, owing to the necessity of a shorter convalescent period, and the need for absolute assurance that the hip would be stable.

Prognosis. In general, it may be estimated that under efficient care, instituted promptly, a stable joint with sufficient motion for the routine functions of life, may be obtained in approximately 80 per cent of the fractures occurring at this site. In 60 per cent of these cases, practically normal motion may be expected, which will allow the patient to be more or less vigorously active. In the 20 per cent remaining, some support may or may not be necessary in walking, and the patient may have a slight limp and experience pain and fatigue, but the hip will be stable, and the motion will be sufficient to allow the patient to perform the ordinary tasks of life.

The failure to obtain union does not necessarily preclude the recovery of a useful limb, and with proper ambulatory apparatus a patient may sometimes be made very comfortable. There were 3 patients in our series who had fair function in spite of the nonunion.

TABLE II.—END-RESULTS—AVERAGE TIME OF POSTOPERATIVE INTERVAL—4 YEARS

Ages	Cases	Method of treatment	End-results			Roentgenographic study of 60 Cases			
			Good	Fair	Poor	Bony	Fibrous	Non-union	Not obtained
30–39	3	Whitman	2	1		2			1
40–49	5	4 Whitman 1 tibial graft	2 1	2		2 1			2
50–59	22	Whitman	15	6	1	10	2	2	8
60–69	33	31 Whitman 1 Boehler 1 reconstruction operation	17 1 1	3	11	7 1 1	4	9	11
70–79	18	16 Whitman 1 Boehler 1 general traction	10 1	4	2 1	6 1	2	4 1	4
80–89	8	6 Whitman 1 Boehler 1 support	4 1	1	1 1	2 1		1	4
Ages unrecorded	2	Whitman	1		1	1			1
Summary	91	84 Whitman 3 Boehler 1 traction 1 support 1 tibial graft 1 reconstruction operation	56	17	18	35	8	17	31
Percentages			61.5	18.7	19.8	58.3	13.3	28.4	

Complications. Among the later complications that are seen when union has occurred is atrophy, and it is seen especially in cases that have not been reduced early and held properly in fixation. Some shortening always occurs, its degree varying with the amount of bone absorption, and depending to a great extent upon treatment. Not infrequently, even with good union, a hip that has been severely damaged will continue to give trouble on account of the arthritic changes that take place in the joints of older individuals.

Limitation of motion of the knee joint is a fairly frequent complication owing to the arthritic changes often present in these senile cases, and to the prolonged immobilization necessitated by treatment in a plaster spica. The firm advocates of open intervention claim that when the limb is treated conservatively in a plaster spica, the patient is left with another disability in the form of a stiff knee. In our experience, we have not found that this sequela is so serious. Surprisingly few of our patients had an arthritic process at the knee joint, and in reviewing our end-results, only a small number complained of any limitation of motion. It is, of course, possible to avoid this complication by using a traction method whenever there is a question as to the outcome.

ANALYSIS OF SERIES OF CASES

Our series of subcapital and transcervical fractures is comprised of 159 cases. (It is unfortunate that our classification of fractures according to their site has not been sufficiently explicit to allow determining the exact number of fractures situated close to the head.) One hundred and forty-three of these fractures were treated by the Whitman method; 6 were treated by the Boehler traction; 1 was treated by general traction; 1, by the Bradford splint; and 1, by support only. Two patients were treated by operation. No treatment was attempted in 5 cases, 4 being elderly patients in poor general condition, and 1 was denied treatment by her family. Approximately 80 per cent of these fractures were treated within a few hours or a few days of the injury. Six patients were treated from 2 to 3 weeks after the fracture, and 9 were treated after an interval of 1 to 2½ months. The delay in treatment was due either to the condition of the patient or to the failure of the attending physician to recognize the fracture.

End-results. A request was sent to each patient asking him to report for examination either to our clinic, or to the physician in his community who had referred him to us for treatment. In case the patient was unable to

report, he was requested to outline in detail his present condition. The difficulty of acquiring data on these cases, the majority of which are elderly at the time of injury, is apparent. We were particularly handicapped by the fact that our series extended over a period of 23 years. Many of the patients had died; many had moved from their former residences; and a few refused examination. Information was secured on 140 cases, and of this number we consider that 91 are suitable for study. We arrive at this conclusion in the following manner:

Total cases		159
Cases not treated	5	
Results unknown	19	
Results unclassified (see explanation below)	13	
Deaths during treatment	31	68
Series used for study		91

As is shown in the accompanying chart, 84 of the 91 cases were treated by the Whitman method; 3 were treated by the Boehler method; 2, by operation; 1 was treated by general traction; and 1, by support only.

In classifying these cases as to the recovery of function, we used the following standard:

Good. Practically normal motion in the hip joint. Walking well without support. No pain. More or less vigorous activity, as walking several miles a day.

Fair. Walking with or without a cane. Good stability. Some limp. Some pain or fatigue. Motion sufficient for ordinary tasks of life.

Poor. Walking with crutches. Pain. Instability. Non-union.

Our estimation of the functional results as based upon this classification showed that 61.5 per cent of the patients secured good functional hips, 18.7 per cent had fair motion, and 19.8 per cent were poor outcomes. In Table II showing the end-results in relation to the ages of the patients, it will be noted that all of the patients under 60 years of age, with the exception of 1, secured satisfactory results, and that 43, or 73 per cent, of the patients over 60 years of age had satisfactory function following treatment.

The percentage of poor results should not be accepted without some explanation. In 4 cases, non-union was the result anticipated from the beginning of treatment; 2 of the patients were over 80 years of age and in poor condition, one refused to co-operate, and the fourth patient had considerable bony atrophy of the upper end of the femur at the time of the injury. If we eliminate these 4 cases in which the presence of associated factors precluded a satisfactory result, the number of poor outcomes averages 15 per cent, a figure that is more encouraging than most of the statistics in literature.

In the so called unclassified group are those cases in which, for some reason, the functional end-result could not be judged accurately. In a few cases the presence of a complicating disease or lesion prevented us from determining the functional outcome; in 4 cases death from an intercurrent disease occurred from 6 to 9 months after reduction; and 1 patient left our care before the after-treatment had been completely carried out.

Roentgenographic study. The acquisition of X-ray material presented even more difficulty than securing the clinical data. Many patients had died, others were too elderly to report for examination, and still others refused to co-operate. Roentgenograms were finally obtained in 60 cases.

Number of cases on which clinical reports obtained		91
Cases in which patients died, but on which friends, relatives, or the family physician sent us clinical reports	16	
Patients refusing to have X-ray	7	
Patients living too far from hospital or office to report	8	31
Number of roentgenograms obtained		60

Thirty-five, or 58.3 per cent, of the 60 roentgenograms showed good bony union; 8, or 13.3 per cent, showed fibrous union; and 17, or 28.4 per cent, showed non-union. These figures should not be accepted as presenting a true roentgenographic study of our series of 91 cases. The discrepancy in 28.4 per cent ununited fractures as estimated from the radiograms, and the 19.8 per cent poor functional outcomes is at once apparent. Had we been able to secure a complete set of roentgenograms, our report on the presence of union would have varied considerably. Figures 4 and 5 show the union in a series of fractures several years after reduction had been obtained following treatment by the Whitman method.

Fig. 1. Vertical views of the femoral neck obtainable with a curved cassette. A, After reduction, with fragments in good apposition; B, fracture with anterior rotary displacement.

Details on deaths. During the course of treatment, that is, within the period of 6 months following reduction, death occurred in 31 cases, making a fatality rate of 20 per cent. This total includes all deaths that occurred within this period, regardless of the cause of the fatal outcome. In order to find out what is the *actual death-rate*, it is necessary to separate those deaths that are directly traceable to the effect of injury and treatment, from those due to an intercurrent disease or to the presence of concomitant factors, such as senility. Of the 31 deaths, only 11 may be traced directly to the effect of the injury and treatment. Eight of these patients died of pneumonia within the first 3 weeks of treatment; 2 patients, both over 80 years of age, died within a few days of the injury; and 1 patient died of an embolus on the fifth day following the reduction. Of significance were the advanced ages of the 8 patients who died of pneumonia, the youngest being 72 years and the oldest 90 years.

Death in all the other cases, with the exception of one on which details are lacking, occurred within 1 to 5 months after reduction. In 7 of these cases, senility and the poor general condition of the patients precluded recovery, as 2 of the patients were in the late seventies, and the other 5 were over 80 years of age. Three patients of this group developed pneumonia. Intercurrent lesions were responsible for the fatal outcome in the 12 other cases. If in our estimation of the mortality rate we eliminate these 19 deaths that are not directly attributable to the fracture, the fatality rate is reduced to 7 per cent, a remarkably low figure (see Tables II and III).

FRACTURES OF THE TROCHANTERIC REGION

The fractures that occur in the trochanteric region may be conveniently classified according to their site as follows:

1. The *intertrochanteric fracture*, in which the line of breakage follows the intertro-

TABLE III.—DEATHS OCCURRING DURING TREATMENT

Total deaths		31
Causes:		
Pneumonia		11
Died within first three weeks of treatment	8	
Ages between 72 and 90 years		
Died late in treatment	3	
Ages, 74, 87, 88		
Intercurrent lesions		19
Died within first week of treatment	3	
Senility, 2		
Embolus, 1		
Died late in treatment:		
Senility	4	
Embolus	1	
Uræmia	2	
Cardiac disturbance	6	
High blood pressure	1	
Cerebral hæmorrhage	2	
Unknown		1
		31
Ages:		
50–59	1	
60–69	2	
70–79	12	
80–89	11	
90	1	
Unknown	4	
		31
Method of treatment:		
Whitman	30	
Boehler	1	
		31
Where treated:		
Home	7	
Hospital	24	
		31

Note.—89 per cent over 70 years of age.

Fig. 2. M.C. Fracture of the neck of the femur in emaciated woman 63 years of age, with pulmonary tuberculosis of long standing. End-result 2 years after reduction by the Boehler traction method, showing solid bony union, with shortening of the neck. Perfect function.

chanteric line and may or may not extend into the trochanters or shaft. In this group are included fractures of the base of the neck.

2. The *transtrochanteric fracture*, in which the fracture line passes across the upper femoral shaft and through one or both trochanters.

3. *Isolated fractures of the trochanters.*

In our experience, the most common site of fracture has been the intertrochanteric area, and 32 of our 56 cases were of this variety. How many of the 32 fractures occurred at the actual base of the neck, we are unable to determine, as it has been our custom to classify such fractures under the intertrochanteric group. Thirteen fractures in our series were situated in the transtrochanteric region, and 5 were isolated fractures of the greater trochanter. No pathological notes are available on the 6 remaining cases.

These fractures, like those of the medial and upper femoral neck, occur most frequently in patients over 60 years of age, and likewise women are affected more often than men. The injury is usually traced to a fall. In isolated fractures of the greater trochanter, the fracturing force is usually direct and violent in nature, while in the etiology of fractures of the lesser trochanter muscle pull plays an important rôle. Displacement is usually slight in these fractures, except when the line of breakage passes directly through the femoral neck, when there is a consequent displacement upward of the trochanter and external rotation of the limb as in fractures of the medial and upper neck. Occasionally in intertrochanteric and transtrochanteric fractures a coxa vara is seen.

Fractures of the trochanteric region are admittedly easier to treat than fractures of the upper neck, since the fracture line passes through bone that has an ample blood supply. A plaster spica or some form of traction is used to hold the fragments in position. Recently we have used the Jones traction splint successfully in treating several of these cases. Union is solid in 2½ to 3 months following the use of this method.

In spite of the ease of treating these fractures, and in spite of the fact that the prognosis is excellent, it is amazing to note the number of cases that are allowed to heal with a lessening of the angle of the neck and shaft. Figure 6 shows a case in which the normal angle was not restored. In the presence of such imperfect mechanical conditions, an arthritic process rapidly develops and gives rise to further disability.

Analysis of 56 cases. Fifty-five cases were treated by a plaster spica, and the Jones traction splint was used in the odd case. Practically all patients had been treated within a few hours or a few days of the time the injury was sustained.

End-results. In the compilation of these end-results, we encountered the same difficulties as in accumulating data on the fractures of the upper neck. As the accompanying chart shows, the majority of patients were over 70 years of age at the time of the fracture and undoubtedly many of the inquiries that were returned unclaimed had been sent to patients who had died. Of the 56 cases, 30 are suitable for study.

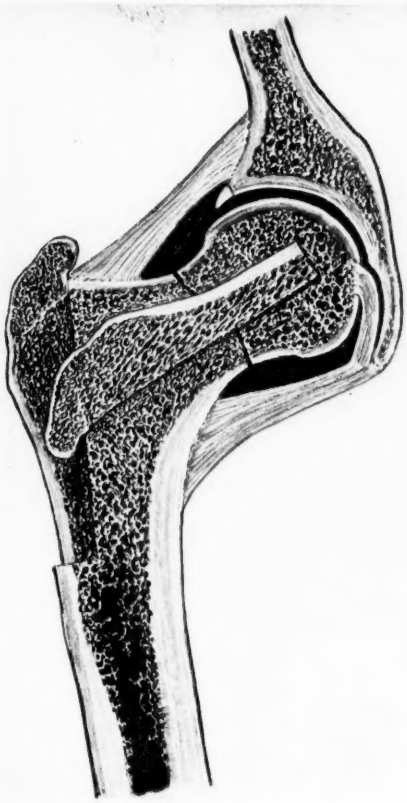

Fig. 3. Bone-graft method of Jones. "Diagrammatic section showing the structure of the bone-graft." (Courtesy of Dr. Jones.)

Total series of cases		56
Results unknown	13	
Results unclassified	4	
Deaths during treatment	9	
		26
Series used for study		30

In the unclassified group there were 2 bedridden patients; there was 1 patient who had had tuberculosis at the time of the fracture and died within 6 months; and the fourth patient tore off the spica on the day following its application and refused further treatment.

In estimating the functional recovery, we used the same standard as in judging the outcome in fractures above the base of the neck.

Fig. 4. R.M. Transcervical fracture in woman 77 years old. End-result 3 years after Whitman reduction. Bony union. Excellent function, with slight limitation of abduction.

The end-results as based on this classification showed that 26, or 87 per cent, obtained good functional joints; 1, or 3 per cent, obtained fair functional motion; and 3, or 10 per cent, were poor outcomes. In one intertrochanteric fracture in which good motion was obtained there remained a slight coxa vara, and another good result was complicated by slight displacement of the greater trochanter. A few cases in which the lesser trochanter was involved showed slight absorption of this process. Four patients complained of arthritis of the knee.

An analysis of the poor results revealed that one patient, aged 79 years and in poor general health at the time of the injury, had been unable to tolerate a regular spica. Another patient aged 78 years was feeble and in poor health. In the third case, which was a badly comminuted intertrochanteric fracture, the shoulder of the distal fragment had been absorbed by the end of the sixth week following reduction. The patient was only 35 years of age.

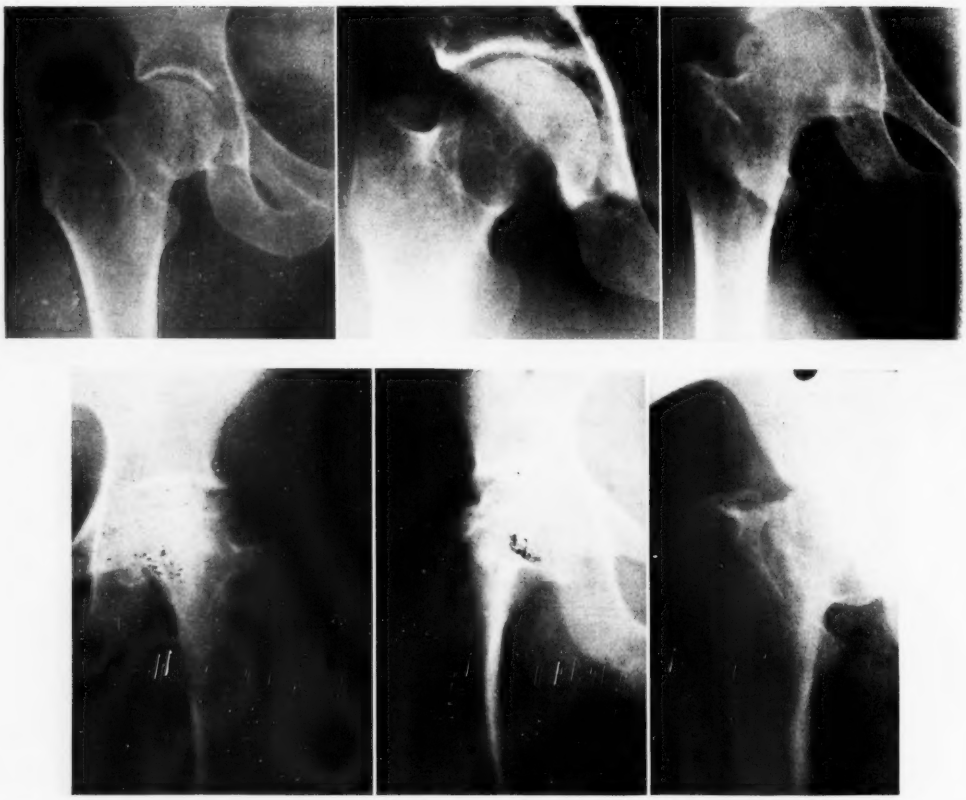

Fig. 5. Roentgenograms of a series of transcervical fractures, taken several years after reduction by the Whitman method. All show bony union and have excellent functional results.

In the acquisition of the roentgenographic material on the trochanteric fractures, we were more fortunate than in compiling data on fractures of the upper neck, and 23 roentgenograms were obtained on the series of 30 cases. Of these, 87 per cent showed bony union, and 13 per cent, non-union.

Analysis of deaths. Nine deaths occurred during treatment, that is, within the 6 months' period following the application of a plaster spica. In 6 of these cases the effect of the injury or of treatment was responsible for death, although the ages of 68, 88, and 98 in 3 cases precluded a satisfactory outcome. Three of these patients died of pneumonia within the first 3 weeks of treatment; 2 died of pulmonary embolus, 1 during the manipulative reduction and the other on the third day after reduction; and 1 patient died of myocarditis on the second day. One patient died of diabetes within the first week of treatment. While the causes of death in the 2 remaining cases of the series were unavailable, we do know that 1 patient died within the second week of treatment, and the other at the end of the third month. If we eliminate these two cases in which we do not know the cause of death, and the case in which death was due to diabetes, the fatality rate is 11 per cent. It will be noted that this death rate is higher than the fatality rate of 7 per cent that we estimated in our series of fractures of the upper neck. Other writers have also called attention to the higher death rate in fractures

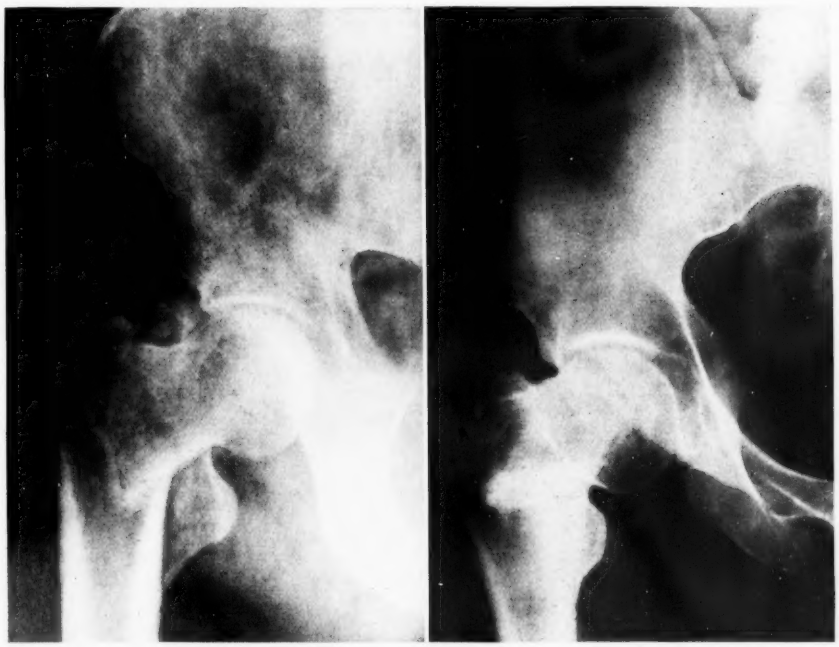

Fig. 6. F.S. Roentgenogram of comminuted intertrochanteric fracture. At left, before reduction; at right, end-result 4 years after reduction, showing good bony union, but slight coxa vara.

of the trochanteric region (see Tables IV and V).

UNUNITED FRACTURES

The determination that a fracture of the femoral neck remains ununited can usually be made with accuracy when, after a sufficient time has been allowed for healing, free motion is demonstrable between the bone-ends, and the roentgenogram shows a line of non-union with absorption of the fractured surfaces. Limited abduction, pain, instability, a spring to the hip, and shortening are other signs indicative of a non-union. The surgeon, in diagnosing these ununited fractures, must ever bear in mind that osteogenesis in this area is slow, and that at least 6 months is required for complete healing in the average case, and from 8 months to a year if complications are present. Unless the slowness of repair is appreciated, it is not unlikely that a delayed healing process, or even a stage of union, will be mistaken for a permanent non-union. (See section on Pathology, Fractures of the Upper and Medial Neck.)

Types of non-union. The non-union may be one of two types. In cases in which the fractured surfaces are kept properly immobilized, the head and shaft may retain their relation to each other during the process of absorption; as a result, when the limb is brought down into normal position, the head is found to sit well upon the projecting portion of the neck. Such a hip is fairly stable, and except for the shortening and the limp, may cause little trouble. The second type of non-union, in which the fragments are no longer in good position, is far more common. The neck has been absorbed, the trochanter is displaced upward, with consequent shortening, and the shaft of the femur is adducted and everted. This type of non-union gives rise to an unstable limb, and the patient suffers pain. As a rule, painful spurs and irritative processes develop, although some hips may resist their formation for years. Such a condition is dis-

Fig. 7. H.D. At left, ununited fracture in woman 60 years of age. At right, end-result 3 years after Brackett operation. Note: The result would have been better had the trochanter been attached lower down on the femoral shaft. Late absorption of the distal shaft was also a complicating factor.

Fig. 8. N.C. End-result 8 years after Brackett operation. Patient was a woman 53 years of age.

abling, and the patient is extremely limited in activity. Crutches are usually necessary, and in time even support may have to be discarded, and the patient becomes a chronic invalid.

Pathology. Upon anatomical dissection the ununited fracture shows many interesting details. The cancellous structure, the cortex, and the cartilage of the capital fragment are markedly atrophied. The end of the fragment is covered with a pannus, on the outer rim of which is attached the new fibrous formation to which we have referred previously. Over the end of the base of the neck is a fibrous covering, which is usually somewhat heavier than the covering of the head. When this covering is removed, the bone is found to be in good condition, the atrophy is only moderate and usually the remains of the old strengthened band in the anterior portion of the cortex are found. Between the fragments can be demonstrated new joint formation, that is, one or more cavities lined with epithelium and containing viscous joint fluid. Under pressure sliding of the opposed joint surfaces upward can be demonstrated, the amount varying

TABLE IV.—END-RESULTS OF FRACTURES OF THE TROCHANTERIC REGION

Ages	Cases	Method of treatment	Type of fracture	Functional end-results			Roentgenographic results		
				Good	Fair	Poor	Bony	Non-union	Not obtained
30–39	2	Plaster spica	1 intertrochanteric 1 transtrochanteric	1		1	1	1	
40–49	1	Plaster spica	Unknown	1					1
50–59	3	Plaster spica	2 intertrochanteric with detached lesser trochanters 1 intertrochanteric with detachment of both trochanters	2 1			1 1		1
60–69	6	5 Plaster 1 Jones splint	2 intertrochanteric 2 intertrochanteric with detached lesser trochanters 1 fracture of greater trochanter 1 impacted intertrochanteric	2 2 1 1			2 2 1 1		
70–79	12	Plaster spica	7 intertrochanteric 1 intertrochanteric with detached greater trochanter 2 intertrochanteric with detachment of both trochanters 1 transtrochanteric 1 unknown	4 1 2 1 1	1	2	4 1 1 1	2	1 1 1
80–89	4	Plaster spica	1 intertrochanteric 2 intertrochanteric with detached lesser trochanters 1 transtrochanteric	1 2 1			1 1 1		1
Unknown	2	Plaster spica	1 intertrochanteric with detached lesser trochanter 1 intertrochanteric with detached greater trochanter	1 1			1		1
Summary	30			26	1	3	20	3	7
Per cent				87	3	10	87	13	

Average time of postoperative interval 4½ years.

from a quarter of an inch to a full inch. When the sliding is minimum in degree, the hip is fairly stable, while the reverse is true of a hip that allows motion of an inch. In our observance of cases of non-union, we have noted that the weight-bearing strain is shunned by the capitulum and is borne entirely by the heavy fibrous ligaments and scar tissue attached to the base of the neck.

Causes of non-union. This is a subject that has been so thoroughly discussed in medical literature that further elaboration is unnecessary. The question of the etiology is still not completely solved, and we cannot yet explain why a case that has been properly treated shows rapid absorption of the neck.

A study of the possible causes of non-union in 27 fractures which were ununited when we saw them for the first time, showed that the following factors played a part:

	Cases
Failure to recognize fracture	4
No particular treatment instituted	3
Traction for a few weeks	5
Plaster applied with limb in improper position, or removed early	8
Questionable treatment, such as fracture "set," or operation performed	4
Absorption of neck following proper treatment	1
Early history unavailable	2

It will be noted that lack of treatment, or faulty treatment, was the primary cause of non-union in practically all these cases, and in only one case had the hip been accurately reduced by the Whitman method, and a plaster spica worn for 6 months. A distressing feature of the 3 cases in which the fracture was recognized, but the patients were allowed to lie in bed with the limb merely protected by sandbags, was that their ages ranged from 29 to 50 years.

A careful study was made to determine the causes of non-union in the 17 poor outcomes in our series of 91 cases. As we explained under the discussion of the results in these cases, non-union was the outcome anticipated from the beginning of treatment in 4 of the 17 cases. In the 13 remaining cases, we were unable to account for the development of non-

Fig. 9. M.C. At left, ununited fracture in a woman 53 years old; at right, end-result 3 years after Whitman reconstruction operation.

union; the fractures had been reduced by the Whitman method within a few hours or a few days of the injury, and a plaster spica worn for a period of 2 to 5 months, when the roentgenogram showed definite extensive absorption of the femoral neck. In 6 of these ununited fractures reconstruction operations were performed.

Treatment. Surgical intervention is the only means of treating non-union and many operations have been advanced for the relief of ununited fractures. The choice of method depends upon the local pathology in the head and neck, and upon the age and condition of the patient. The selection will vary, too, with the operative experience of the surgeon. No arbitrary limits should be set as to the period of non-union when different procedures are applicable, as some cases will be suitable for a bone-graft at the end of several months, while in other cases the hip may be well preserved after more than a year's time.

We shall discuss the various methods of treatment under two groups:

A. Methods applicable when both fragments are well preserved, or when the capital fragment is preserved, but the neck more or less absorbed.

B. Methods applicable to cases in which the femoral head is destroyed and the neck atrophied.

A. When the head and neck are fairly well preserved, and when it is possible to pull the trochanter down into position, the autogenous bone-graft method of either Albee or Jones is the operative procedure of choice.

In ununited fractures in which the head is preserved, but the neck more or less absorbed, thus making the use of a bone-graft impractical, the method described by Brackett, or a method that has been mentioned by several writers and more recently has been described by Magnuson, is to be recommended. The Brackett procedure consists of

placing the freshly exposed surface of the trochanter in contact with the hollowed-out head, and lowering the attachments of the trochanter on the femoral shaft. It aims thereby to provide a source of viability for the capital fragment. Brackett first described this operation in 1917. On reviewing our cases, we find that Dr. Andrew MacAusland carried out practically the same technique in a case in November, 1916. The patient, a woman aged 52 years, had had an ununited fracture of 3½ years' duration. When the joint was exposed at operation, the neck was found to have disappeared, except for its lower anterior fragment. This fragment and a section of the trochanter with its muscle attachments were removed. The head was hollowed out, and the remodeled shaft and trochanter were placed in apposition with it. The section of the trochanter with its attachments was replaced against the side of the femoral shaft as low down as possible.

It will be noted that this technique differs from that described by Brackett, in that the section of the trochanter is removed with the muscle attachments, and fixed lower down on the shaft. Brackett, on the other hand, removes simply a small layer of bone with the attachments, for re-attachment later, and then removes and discards a section of the trochanter to create a fresh surface for contact with the femoral head.

Since 1916, we have used this technique, modified only as to the operative approach, in 8 other cases. Better exposure of the joint is obtained by a regular U-shaped incision. Our results may be seen in Table VI. The preoperative and postoperative radiographic findings in one of these cases are seen in Figure 7. The patient at this time (11 years after the operation) has good function in her hip. Another result in a hip that was treated 8 years ago is seen in Figure 8. The patient now walks with a cane and is able to do light housework.

The method described by Magnuson, which is often confused with the Brackett operation, involves cupping out the head, inserting the freshened neck fragment, and re-attaching the trochanter with its attached muscles at a lower level on the femoral shaft. It is apparent that this procedure more than any other aims to re-establish normal anatomical relations. Provided the pathology allows its application, and provided a good articular surface remains to assure a joint with free motion, it is a method to be recommended. Our experience with the method has been limited to 4 cases (see Table VI).

TABLE V.—DEATHS OCCURRING DURING TREATMENT

Total deaths		9
Died of pneumonia		
Within first 3 weeks	3	
Died of intercurrent lesions		
Within first week		
Pulmonary embolus	2	
Myocarditis	1	
Diabetes	1	
Died of unknown cause	2	
		9
Ages:		
40–49	1	
50–59	1	
60–69	3	
70–89	2	
90	1	
Unknown	1	
		9
Method of treatment		
Plaster spica		9
Where treated		
Home	0	
Hospital	9	
		9

B. In ununited fractures in which, because of the extensive pathology, it is impractical to attempt restoration of even approximately normal relations, some type of reconstruction operation becomes necessary. The great majority of ununited fractures are of this class. The head is absorbed, the neck atrophied, and the trochanter is displaced upward to a marked degree. By means of a reconstruction operation, a hip joint may be created that is sufficiently stable for weight-bearing and allows a fair amount of function.

There are three well known methods of reconstruction: the Whitman (15) method, the Albee (2) method, and the Lorenz (11) method. Of these, the Whitman method has been used most extensively. The function following its use is not, of course, so satisfactory as that following the Brackett or the bone graft operation, and some pain may be experienced in view of the fact that the remodeled trochanter does not fit the acetabulum accu-

TABLE VI.—RESULTS OF OPERATIVE TREATMENT OF UNUNITED FRACTURES

Method of treatment	Cases	Ages	Functional results				Roentgenographic results			Died during treatment
			Good	Fair	Poor	Unknown	Good union and good position	Displacement	Unknown	
Whitman method	16	33–68	12		1	2	8	1	7	1—surgical shock
Brackett method	9	40–60	3		1	2	3	Non-union 1	5	2—sepsis 1—pneumonia
Method described by Magnuson	4	40–60		1	1	2			4	
Albee method	1	53	1						1	
Freshening of bone-ends	3	29–67	1 Non-union		1	1		Non-union 2	1	
Fixation by nail	1	38			1			Non-union 1		
Construction of shelf in acetabulum	1	41				1			1	

rately, but it is the best means of providing a secure skeletal support. We have used this method in 16 cases and obtained excellent results. Figure 9 shows the pre-operative and postoperative radiographic findings in one of this group of cases. The patient has a remarkable range of motion; she limps only slightly, is able to go up and down stairs, and does all her own housework.

The Albee method of forming a bone lever is more complicated in design, and for this reason has not been more generally used.

The Lorenz method differs from the other two procedures in that it does not aim to restore the original mechanics of the hip joint, but rather to construct a neoarthrosis of sufficient strength to support the body. The method has been little used in this country, and the number of cases in which it has been carried out is still too small to allow drawing conclusions as to its value.

Table VI outlines our operative treatment of ununited fractures. The ages of the patients ranged from 29 to 68 years. The lack of treatment, or improper treatment, was the primary cause of non-union. The classification that we used in judging the functional end-results is as follows:

Good. Excellent stability, a good range of motion, no support necessary in walking, practically no pain or fatigue, and ability to pursue ordinary activities. Always slight limp.

Fair. Good stability. Ability to get about fairly well and do light work. May or may not use a cane. Some pain and fatigue.

Poor. Unable to walk without crutches. Pain and fatigue. Marked shortening.

It will be noted that 12, or 86 per cent, of the cases in which we used the Whitman method obtained good results. It is unfortunate that we are unable to obtain the roentgenographic reports on all cases.

Our experience with the Brackett and the Magnuson methods has been limited, and on the whole, the results have not been satisfactory. We believe, however, that the methods are to be recommended. Freshening of the bone-ends, as carried out in 3 of our early cases has, of course, been discarded as a method of treatment. The case in which the fixation by nailing was done was also one of our early cases, as was the case in which the acetabulum was deepened and the femoral shaft placed in apposition with it.

SUMMARY AND CONCLUSIONS

This study of fractures of the femoral neck is based on a series of 250 cases that were treated throughout a period of 23 years. One hundred and fifty-nine cases were fresh fractures situated in the medial and upper femoral neck; 56 were of the trochanteric region; and 35 were ununited fractures. Sixty-six per cent of the patients were 60 years of age or older at the time of the injury.

Of the 159 fractures of the medial and upper neck, the results in 91 cases were considered suitable for study. All but 7 cases had been treated by the Whitman method of reduction and in 80 per cent the treatment had been

carried out within a few hours or a few days of the injury. The functional results, as judged after an average time interval of 4 years, were as follows: good, 61.5 per cent; fair, 18.7 per cent; and poor, 19.8 per cent. The roentgenographic study, which was based on the 60 roentgenograms available, showed 58.3 per cent bony union, 13.3 per cent fibrous union, and 28.4 per cent non-union. (The discrepancy in the percentages of ununited fractures as based on the functional results and on the roentgenographic study is apparent, and is due to our inability to obtain roentgenograms of all cases.) The total number of deaths occurring within the 6 months' period following reduction was 31, or 20 per cent. Of this number, only 11, or 7 per cent, could be traced directly to the effect of the injury and treatment.

The Whitman method of reduction has, therefore, proved to be effective in establishing joints that are stable and that allow sufficient motion for the routine functions of life, in 80 per cent of our cases. We aim, of course, to increase the number of satisfactory results in these fractures, but in view of the many factors that are unfavorable to union, in particular the absolute lack of capacity for repair that may exist, the question arises as to how much we may expect to better the work in this field. Undoubtedly, the early recognition of cases in which treatment by traction methods or by operative intervention is indicated will help to improve our results. The newer traction methods, which tend to eliminate the difficulties of the older forms, hold much promise. Surgical intervention, in our opinion, is applicable to only a small group of cases, selected carefully as to age and general physique, in which it is evident that the Whitman method would not be efficient. Of the operative methods in use, we prefer the bone graft method. We are opposed to methods that incorporate the use of a foreign body. The applicability of both traction and operative methods is still limited to a relatively small number of cases, and the Whitman method is the treatment of choice in the majority of cases. Until this method is superseded by one as practical, and by one so simple of execution that it can be carried out by all operators, the Whitman method will continue to be the established treatment used for this type of fracture.

Of the 56 fractures of the trochanteric region, 30 were considered suitable for study. Eighty-seven per cent resulted in good function, 3 per cent in fair function, and 10 per cent in non-union. The death rate was 11 per cent. All cases, with the exception of one in which a Jones splint was used, had been treated by a plaster spica.

In our group of 35 ununited fractures there were 17 in which non-union was the result of our treatment. In 13 of these cases we were unable to account for the outcome; the fractures had been reduced within a few hours or a few days of the injury, and the plaster spica worn for 2 months or longer, when the roentgenogram showed extensive absorption of the neck. In the 4 other cases, the non-union was the anticipated result, owing to the presence of complicating factors. The most common causes of non-union in the group of 27 cases that were ununited when they first came to us for treatment were lack of early treatment and faulty treatment.

Our treatment of ununited fractures has been limited chiefly to the Whitman reconstruction operation. In the 16 cases in which this method was carried out, 86 per cent good results were obtained. When the pathology permits, we would recommend the bone graft operation of Albee or Jones, the Brackett operation, or the method recently described by Magnuson.

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THE EFFECTS OF INCREASED INTRAGASTRIC PRESSURE UPON THORACIC AND ABDOMINAL ARTERIAL AND VENOUS PRESSURES

CHARLES W. McLAUGHLIN, JR., M.D., AND J. WALTER LEVERING, M.D., PHILADELPHIA
From the Laboratory of Research Surgery and the Department of Surgery, Surgical Division C, University of Pennsylvania, School of Medicine

THE term acute gastric dilatation is usually associated with the late stages of increased intragastric tension. That the condition exists frequently in varying degrees is not so generally recognized. Careful study of patients after operation has convinced us that the lesion is often a progressive one. In its earliest phases the patient may complain of no symptoms although the lesion can be demonstrated by percussion, by roentgen-ray examination, or by the use of any tube which can be used for gastric syphonage. In its later stages the distended abdomen, the voluminous vomiting, and the increasing illness of the patient make the diagnosis a simple matter.

Much has been written on the supposed mechanisms which produce gastric dilatation. The effect of fluid loss on the volume of the circulating blood has also been discussed and the effect of salt loss on the blood reaction has received considerable attention. That changes in the gastric tension may have profound primary effects on the cardiovascular system is not so well recognized.

Plumier, Thorington and Schmidt, Frey, Dmitrenko, McIver, and Runge have studied the effect of increasing the abdominal pressure on the arterial or venous pressures or both. We have not been able to find any similar studies where these pressures were measured when the stomach was subjected to acute changes in the intragastric tension, except the short report of Dmitrenko. While these studies were being made Brams, Katz, and Kohn reported the effect of abdominal distention and release on the blood pressure in the carotid artery and the veins above and below the diaphragm. In the experiments reported in this paper we have not only reproduced the picture of acute gastric distention as observed in clinical cases, but we have utilized pressures which we are sure exceed any commonly observed. However, since the progressive increases in pressure in the animal were induced over a relatively short period, there was not the profound loss of blood volume which may occur when the condition is more prolonged in its onset. The terminal effects on the cardiovascular system in acute gastric dilatation in the human are, therefore, probably even greater than our experiments disclose from mere acute increases in the gastric pressure.

METHOD

Dogs anæsthetized with sodium amytal, 50 milligrams per kilogram of body weight, were used as the experimental animals. A tube was introduced into the stomach through the œsophagus. A midline abdominal incision was then made, the tube was tied in place at the cardia and the pylorus firmly closed by stout ligatures. The abdomen was then closed by tier suture. Cannulas were introduced into the carotid and femoral arteries, the inferior vena cava through the femoral vein, and into the thoracic veins through the external jugular vein. Pressure changes in the veins were determined by means of a 1 millimeter bore straight manometer filled with 6 per cent sodium citrate. The stomach of the animal was then distended with air, the degree of distention being measured by a mercury manometer which was connected with the gastric tube through a side arm. Fluctuations in the arterial and venous pressures and the pulse rate, with variations in the intragastric tension were then recorded on a kymograph. All animals were kept in the supine position during the experiment. All the experiments were of the acute type, the animal being sacrificed at the completion of the experiment. The arterial and venous pressures given in the succeeding data are the means obtained at the particular moment.

Results. Venous pressure. Whenever the intragastric tension was increased the pressure

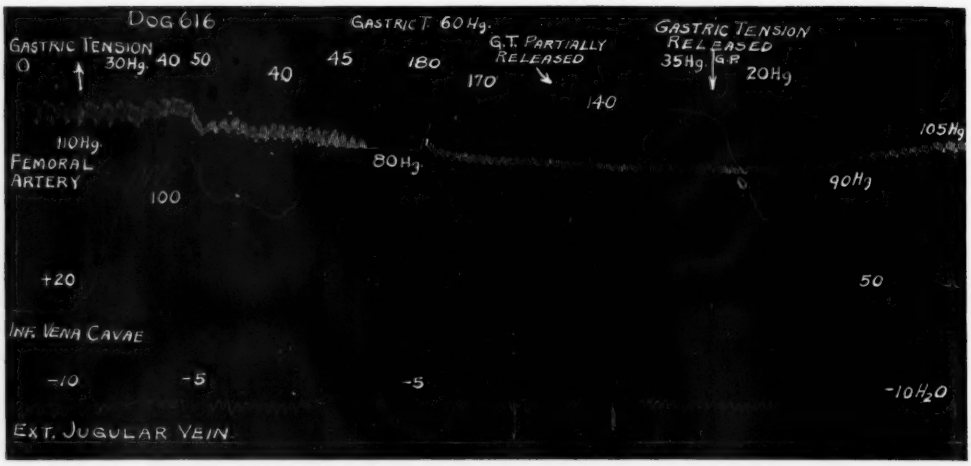

Fig. 1. The effect of intragastric tension upon the femoral and superior and inferior caval pressures.

in the inferior vena cava rose promptly. With increasing gastric pressures there was an increase in the inferior caval pressure. The initial mean pressure in the inferior vena cava was approximately 10 millimeters of the citrate solution. When the pressure in the stomach was increased to 30 millimeters of mercury the mean inferior caval pressure rose to approximately 60 millimeters of the citrate solution. When the intragastric tension was gradually increased to 150 millimeters of mercury, the mean inferior caval pressure rose to approximately 300 millimeters of the citrate (Fig. 1). Release of the intragastric tension resulted in a prompt fall in the inferior caval pressure to approximately its initial level.

The initial mean pressure in the superior vena cava was approximately −10 millimeters of the citrate solution. Slight increases in the intragastric tension caused no change in the superior caval pressure. When, however, this pressure reached 30 millimeters of mercury there was in nearly every experiment a slight rise in the mean superior caval pressure. A gastric pressure of 50 millimeters of mercury caused a rise of approximately 15 millimeters of citrate and an intragastric pressure of 100 to 150 millimeters of mercury resulted in a rise of 20 to 30 millimeters of citrate (Fig. 2). This was the maximum superior caval pressure which we observed. Release of the increased intragastric pressure resulted in a prompt fall of the superior caval pressure to approximately its initial mean value.

Arterial pressure. As the intragastric pressure was increased there was usually observed a fall in the femoral pressure which, when the intragastric pressure reached 30 to 50 millimeters of mercury, averaged 15 millimeters of mercury (Fig. 3). At times the reduction in the femoral pressure was rapid while at others it was slow. The femoral pressure usually continued to fall until the intragastric pressure reached 50 millimeters of mercury when it as a rule began to rise. In some experiments the fall continued (Fig. 1) while in still others (Fig. 4) no initial fall was observed, but on the contrary a rise in the femoral pressure was observed until the intragastric pressure reached 70 to 80 millimeters of mercury when a fall occurred. When the femoral pressure rose the pulse pressure decreased, and when the gastric pressure was increased above 60 millimeters of mercury the mean femoral pressure frequently rose from 10 to 15 millimeters above the initial pressure.

Increasing the intragastric pressure to 110 millimeters or above frequently caused a sudden drop in the femoral pressure to approximately the initial mean pressure, or even lower than this, while at the same time the pulse pressure suddenly disappeared. If at

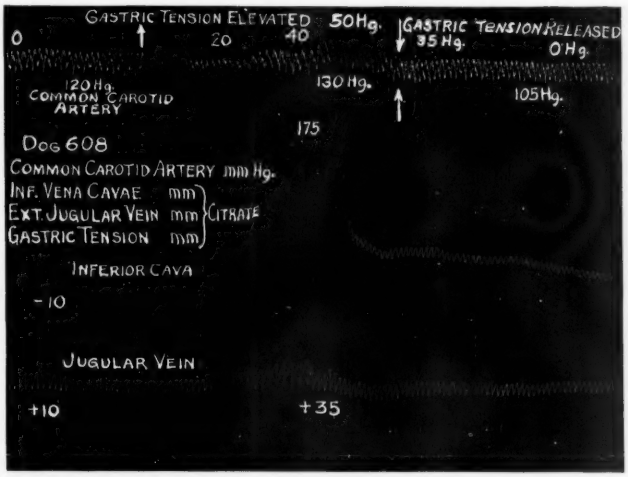

Fig. 2. The effect of intragastric tension upon carotid and superior and inferior caval pressures.

this time the femoral cannula was removed blood flowed slowly from the proximal portion of the artery without the characteristic spurts. The femoral pressure was maintained at this lowered level until the intragastric tension was released when the pressure immediately rose, frequently going above the initial value and at the same time there was a restoration of the pulse pressure. The transient rise in the femoral pressure when this occurred was followed by a rapid return to its original level.

The pressures in the carotid artery did not always parallel those in the femoral artery. With an intragastric pressure of 30 millimeters of mercury there was often a fall in the common carotid pressure similar to that observed in the femoral artery (Fig. 3). This persisted until the intragastric pressure reached from 50 to 60 millimeters. Associated with the fall in the carotid pressure there occurred at times a decrease in the carotid pulse pressure.

Increasing the intragastric tension above 60 millimeters of mercury resulted in a rise of the carotid pressure to its original level. As the gastric pressure was further increased the carotid pressure rose above its initial level and there was frequently a marked increase in the pulse pressure while at the same time the femoral pulse pressure disappeared (Fig. 3).

When the intragastric pressure was suddenly released the carotid pressure usually fell 10 to 15 millimeters below its original level. As a rule it then returned rapidly to its normal value and the pulse pressure became similar to that observed before the gastric pressure was increased.

In some experiments the initial fall in the carotid pressure was not observed as the intragastric tension was increased (Fig. 4). Instead, the carotid pressure rose while at the same time the pulse pressure frequently increased. The elevation in the carotid pressure was maintained until the increased intragastric tension was released.

DEDUCTIONS

The changes in the venous and arterial pressures are in many ways similar to the changes observed following increases in the intraperitoneal pressure. That these changes do have considerable effect on the cardiovascular system is beyond question.

The rise in the inferior caval pressure is undoubtedly due to local block of the inferior vena cava proximal to the point where the pressure was determined. Although we have not measured the portal pressure in these experiments we have observed that when the

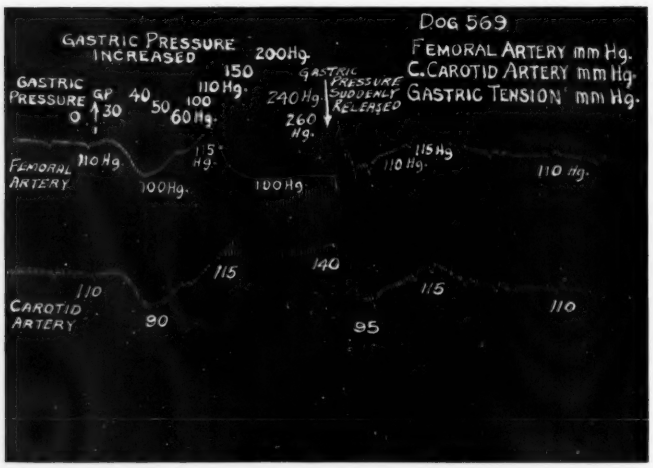

Fig. 3. The effect of intragastric tension upon the carotid and femoral pressures. Note the marked difference in these pressures when the intragastric tension reached 110 millimeters of mercury.

abdomen was rapidly opened after the intragastric pressure had been markedly increased there was definite evidence that the portal flow was also obstructed.

The series of events which took place as the intragastric pressure was increased may be given as follows: If considerable blood was forced from the area below the diaphragm into the heart, the common carotid pressure would increase while if the increasing intragastric pressure rapidly obstructed inferior caval and portal blood flow to the heart and the elevated diaphragm further limited the cardiac output, a temporary fall in arterial pressure would result.

The maintenance of the high inferior caval pressure was probably the result of several factors. In the first place, the vascular bed distal to the obstruction may have, within a very short time, reached its maximum capacity or any increase in the size of this bed was rapidly taken care of by the blood forced into it from the arterial side. In the various discussions on the effect of intraperitoneal distention on the cardiovascular system, no reference is made to the communications which exist between the arteries and veins above and below the diaphragm. That there is an extensive venous and arterial pathway through vessels normally present in and around the vertebral column is beyond question. There is also the opportunity for communication between the intercostals and lumbar vessels and with the azygos vein. It may well be that at the highest venous pressure which we obtained certain of these pathways were opened sufficiently to prevent a further rise in the venous pressure.

The slight rise in the pressure in the superior vena cava may have been due to changes in the intrapleural pressure associated with the elevation of the diaphragm. It may also have been contributed to by an increased flow of venous blood through the various channels enumerated above resulting in an increased flow through the superior vena cava.

While the fall in the carotid and femoral arterial pressures may be explained on the reduced amount of blood available for the circulation as the result of the block below the diaphragm, the subsequent rise in these pressures requires further explanation.

The rise in the arterial pressures when the intragastric tension was increased above 60 millimeters of mercury may in part have been due to vasoconstriction in the head, neck, and upper extremities, but it may also in part have been due to arterial blood carried to the

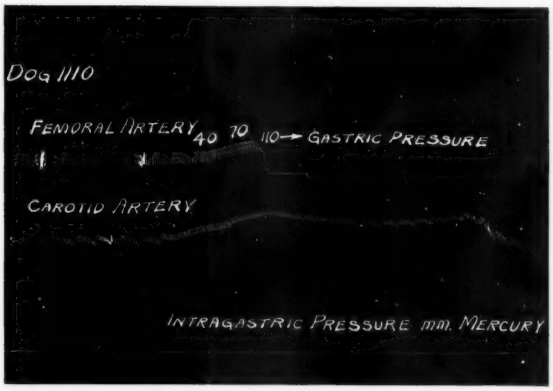

Fig. 4. The effect of intragastric tension upon caval and femoral pressures. In this experiment both pressures rose until the intragastric pressure reached 110 millimeters of mercury.

inferior arterial circulation through vertebral anastomoses and to venous blood being carried from the inferior to the superior circulation.

The sudden disappearance of the femoral pulse pressure was, we think, due to the arterial tamponade resulting from the greatly distended stomach which caused a markedly increased peripheral resistance just below the diaphragm. It may be thought that the tamponade at very high intragastric pressures caused complete aortic occlusion. If this were true the pressure in the vascular bed distal to the point of constriction was sufficient constantly to maintain a pressure of 90 millimeters of mercury. In the presence of the several minor pathways for venous return this would hardly seem probable. The fact that bleeding occurred from the proximal end of the femoral artery when the cannula was released in several instances is proof that in those experiments in which this occurred some blood was able to pass the point of tamponade and it is likely that some arterial blood constantly found its way into the area below the diaphragm through anatomotic channels.

The marked increase in the carotid pulse pressure which was at times observed during the period of disappearance of the femoral pulse pressure may have been the result of mechanical factors causing an alteration in the dynamics of the superior circulation. At this time the respiration is embarrassed by the greatly distended stomach which results in fixation of the low portion of the costal arch, and the heart occupies a more transverse position in the thorax. The aortic and carotid sinus reflexes play no part in this mechanism because it has been observed when the vagi were divided and the carotids ligated. The elevation of the pressure in the carotid at this period may also be influenced by tamponade of the abdominal aorta which acts to increase the peripheral resistance in the aorta.

The rapid return of the arterial and venous pressures to their original levels when gastric distention which had been maintained for only a short period was released, is good reason for the early relief of gastric dilatation in the human. Brams, Katz, and Kohn have observed that after the release of marked abdominal distention which had persisted for some time the fall in the arterial pressure was as much as 40 millimeters of mercury. They wisely caution that such a drop "in a feeble patient might result in death."

The rapid release of the intragastric pressure even when this had been maintained for only a short period, resulted in profound changes in the arterial system. When the tamponade of the abdominal arterial and venous system is suddenly released, the readjustment of the circulation depends upon

the rapidity of the restoration of the normal factors controlling it.

Of considerable importance in acute gastric dilatation is the added reduction of the blood volume. Large quantities of fluid and considerable amounts of salt may be lost through vomiting. This may further result in a shift in the acid-base balance. Even when the tension is only moderately increased there must occur a considerable reduction in the blood volume as a result of the increasing venous pressure in the veins below the diaphragm. In a number of dogs bloody fluid was found in the stomach and intestines at the conclusion of the experiment. It is well known that portal obstruction results in a marked loss in the blood volume. This must be considerably greater when added to portal obstruction there occurs inferior caval tamponade.

Freeman, Morison, and Sawyer have recently shown that acute dehydration stimulates medullo-adrenal secretion and Freeman had previously shown that adrenal secretion causes a still further reduction in the blood volume.

There results, therefore, a series of events which act in a vicious circle to cause a steady progression of symptoms once the mechanism of acute gastric dilatation is initiated. The mere replacement of the fluid vomited is insufficient to relieve the patient. Of primary importance is the release of the cause of the primary factor causing the circulatory changes. Of greater importance to the patient is the prevention of any increase in the intragastric tension by continuous gastric syphonage as suggested by Paine, Carlson, and Wangensteen.

CONCLUSIONS

1. Increases in the intragastric tension may cause profound changes in the cardiovascular system.

2. The inferior caval pressure progressively increased as the intragastric tension rose to 150 millimeters of mercury.

3. There resulted also an obstruction to the portal blood flow.

4. Marked changes are observed in the carotid and femoral blood pressure.

5. Evidence is presented to show that the distended stomach may cause tamponade of the abdominal aorta.

6. The primary cardiovascular effects are further exaggerated by the fluid lost by vomiting and into the intestinal tract.

7. The circulatory changes can only be prevented by preventing increases in the intragastric tension.

The authors wish to thank Dr. I. S. Ravdin for his constant interest and many helpful suggestions during the progress of the problem.

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THE DISAPPEARANCE OF BLOOD FROM THE CEREBROSPINAL FLUID IN TRAUMATIC SUBARACHNOID HÆMORRHAGE

The Ineffectiveness of Repeated Lumbar Punctures

WILBUR SPRONG, M.D., Montreal, Canada
Department of Neurology and Neurosurgery, McGill University and the Royal Victoria Hospital, Montreal

THE cerebrospinal fluid has, under normal conditions, a fairly constant composition. It contains no substances not present in blood plasma, practically no colloid material, and very few cells. Red blood cells and fibrin are wholly foreign substances and Bagley has produced experimental evidence that blood in the subarachnoid space is at once harmful and may result in permanent meningeal and nerve tissue damage.

Repeated withdrawal of spinal fluid has been widely advocated for eliminating blood from the subarachnoid space. Patients with subarachnoid hæmorrhage treated by repeated lumbar punctures show a rapid disappearance of blood from the spinal fluid, and undue credit is easily given to the lumbar drainage, overlooking the rôle of processes by which nature clears the subarachnoid space of foreign matter.

The purpose of this study has been to gather data on the disappearance of blood from the cerebrospinal fluid in traumatic cases and to determine the true value of repeated drainage of amounts of spinal fluid considered safe in traumatic cases in hastening the return of the fluid to its normal chemical and acellular state. The rate at which nature achieves this spontaneously and the effectiveness of repeated lumbar punctures are critically analyzed.

METHODS OF INVESTIGATION

Human cases of subarachnoid hæmorrhage. A series of 15 cases[1] with blood in the spinal fluid were treated in three groups. Group I consisted of 5 cases which were given lumbar punctures once or twice a day with a sixteen-gauge needle and the withdrawal of relatively large amounts of fluid. At the first puncture a radical reduction in pressure was always felt to be unsafe and in no case was the pressure reduced to lower than two-thirds of its initial level in the horizontal position. In all subsequent punctures the pressure was reduced at least to one-half. In this way from 15 to 37 cubic centimeters of fluid was removed daily. In 2 of these cases the pressure was consistently reduced to zero at each puncture after the first.

Group II consisted of 8 cases given daily lumbar punctures with a twenty-gauge standard needle or an 0.8 millimeter Labat's needle and the withdrawal of only 1 to 6 cubic centimeters of fluid.

Group III consisted of 2 cases in which a diagnostic puncture was performed on admission and a second puncture after 5 days in 1 and 6 days in the other.

From cell counts and the volume of the fluid obtained a fairly close estimate of the blood removed by each puncture was possible. The method used in treating these data is explained in detail in a subsequent analysis of a typical case.

Animal experiments. In order to amplify the data obtained in human cases where all determinations of blood in the cerebrospinal fluid are necessarily limited to spinal samples, a series of 7 dogs were studied. Here it was possible to obtain all of the cerebrospinal fluid after various intervals following the introduction of measured amounts of blood into the subarachnoid space.

Each dog was anæsthetized with either chloroform or amytal and a cisterna puncture performed. Two cubic centimeters of fresh blood from the saphenous vein were then injected slowly into the cisterna magna. A red cell count was made on the blood used in each case in order to estimate closely the number of corpuscles introduced. After intervals varying from 1 hour to 7 days all of the cerebrospinal fluid was removed as follows:

[1] Thirteen of these cases had traumatic subarachnoid hæmorrhage and 2 were postoperative.

TABLE I

Patient	Age	Estimated cerebrospinal fluid capacity	Number of punctures	Average daily removal of spinal fluid	Days required for fluid to clear	Initial red blood cell count, cells per c.mm.	Estimated amount of blood extravasated into cerebrospinal fluid		Amount of blood eliminated by lumbar punctures		Percentage of estimated blood removed by punctures
		c.cm.		c.cm.			Number red blood cells	c.cm.	Number red blood cells	c.cm.	
P.V.	31	150	6	13	5	22,000	3280×10^6	0.66	345×10^6	0.07	11
E.D.	12	150	11	21	6	26,700	4000×10^6	0.80	410×10^6	0.08	10
M.B.	11	100	7	23	6	680,000	68000×10^6	13.60	10400×10^6	2.08	15
N.M.	10	100	8	18	6	160,000	16000×10^6	3.20	3460×10^6	0.69	22
J.R.	14	150	6	23	5	250,000	37500×10^6	7.50	1545×10^6	0.31	4

Under chloroform or amytal anæsthesia, a laminectomy was performed, the caudal end of the spinal meningeal sac being exposed. This sac was tightly ligated near the tip well below the conus medullaris and cut free distal to the ligature. A venous cannula was then tied into this slender sac exactly as it would be tied into a vein. Thus a bloodless cannulation of the subarachnoid space was obtained with no possibility of fluid leak. By placing the animal in a vertical, tail-down position with the nose elevated as high as possible and introducing air to displace the fluid, the ventricles and subarachnoid space were completely drained. To be further assured that no appreciable fluid remained in the system a cisterna puncture was then performed and an excess of air injected until it escaped freely from the lumbar cannula.

Various fractions of the fluid were prepared for microscopic study by fixing the cells with iodine fumes shortly after the fluid was taken, as advised by Kubie and Schultz.

RESULTS

Human cases of traumatic subarachnoid hæmorrhage. A detailed analysis of the following case will illustrate the method used in analyzing the results of lumbar drainage and demonstrate the rapidity with which blood uniformly disappeared from the spinal fluid:

N. M., a 10 year old girl, was admitted to the Neurosurgical Service at the Royal Victoria Hospital following a blow on the head which resulted in an extensive skull fracture through the sagittal suture. There was no bleeding from ears, nose, or mouth. There was intermittent unconsciousness and vomiting for several hours following the accident and complete dissociation of eye movements. No other localizing neurological signs were found. On admission the spinal fluid was grossly very bloody. Twelve cubic centimeters were removed. A small fraction obtained first and a similar final specimen were counted separately. The initial specimen contained 39,000 red cells per cubic millimeter, while the last had 160,000. The greater concentration of cells in the last fluid obtained shows clearly that the source of the blood was not the lumbar puncture. The separate examination of the first few drops and the last few drops of fluid obtained eliminates the possibility of mistaking bloody fluid from a traumatic puncture for that arising from an intracranial hæmorrhage. In this 10 year old girl the total cerebrospinal fluid capacity may be estimated to be about 100 cubic centimeters. A considerable error in this rough estimate would not change notably the relative values in the following calculations:

The estimated total one hundred cubic centimeters of cerebrospinal fluid in this patient on admission contained at least[1] $100\times1000\times160{,}000$ or $16{,}000\times10^6$ red blood cells. At the first puncture $12\times1000\times160{,}000$ or 1920×10^6 red cells were removed. Likewise the second puncture eliminated 15 cubic centimeters of fluid containing 25,000 red blood cells per cubic millimeter or a total of 375×10^6 red cells. In this way from the cell count and volume of each fluid specimen curve I, Figure 1, is obtained representing the rate of blood removal accomplished by repeated lumbar punctures.

The rate of actual disappearance of red cells determined by counting each specimen of fluid is represented in curve II, Figure 1. The tremendous discrepancy between curves I and II represents spontaneous elimination

[1]Strong evidence was obtained by animal experiments described below that this estimate is actually only a small fraction of the blood initially extravasated.

TABLE II

Patient	Age	Estimated cerebrospinal fluid capacity	Number of punctures	Average daily removal of spinal fluid	Days required for fluid to clear	Initial red blood cell count, cells per c.mm.	Estimated amount of blood extravasated into cerebrospinal fluid		Amount of blood eliminated by lumbar punctures		Percentage of estimated blood removed by punctures
		c.cm.		c.cm.			Number red blood cells	c.cm.	Number red blood cells	c.cm.	
H.R.	46	150	6	3	6	14,250	2130×10^6	0.43	150×10^6	0.03	7
C.F.	30	150	6	3	6	32,000	4800×10^6	0.96	550×10^6	0.11	10
J.K.	12	120	6	6	5	800,000	96000×10^6	19.20	8900×10^6	1.78	9
C.C.	9	100	5	3	4	210,000	21000×10^6	4.20	1265×10^6	0.25	6
S.S.	18	150	6	3	5	11,500	1625×10^6	0.32	88×10^6	0.02	5
A.S.	54	150	6	3	6	27,500	3525×10^6	0.71	180×10^6	0.04	5
*E.W.	14	150	4	6	4	24,000	3600×10^6	0.72	401×10^6	0.08	11
*D.S.	17	150	6	4	6	21,500	3225×10^6	0.65	125×10^6	0.02	4

*Blood in spinal fluid following craniotomy.
All other cases were traumatic.

of cells. Similar curves for all other cases in this group show the futility of spinal punctures even more strikingly. Only from 4 to 22 per cent had been removed by lumbar drainage by the time the fluid had completely cleared.[1] Irregularities in curve II such as the rise to 57,000 cells on the third puncture, are perhaps due to small amounts of blood introduced by the puncture needle and only serve to diminish the discrepancy between the two curves representing spontaneous fluid clearance.

Table I summarizes the results on all cases in Group I. Even though as large amounts of spinal fluid were withdrawn as safety permits in each case it is clear that the value of lumbar punctures was negligible.

Table II presents a summary of results on cases in Group II. Here with the removal of only very small amounts of fluid all blood disappeared just as quickly as in Group I.

In the two additional cases which constituted Group III following a diagnostic puncture on admission, no further punctures were done until the fluid had cleared spontaneously:

CASE 1. G. V., aged 12 years. On admission the spinal fluid contained 62,000 red blood cells per cubic millimeter. Six days later the second puncture was done and the spinal fluid was found clear and colorless and contained only 70 red blood cells per cubic millimeter and 20.1 milligrams per cent proteins.

CASE 2. M. M., aged 27 years. On admission the spinal fluid contained 26,500 red blood cells per cubic millimeter. When the second puncture was performed 5 days later the spinal fluid was clear and colorless and contained 30 red blood cells per cubic millimeter and 23.2 milligrams per cent total proteins.

Blood disappeared from the spinal fluid just as quickly in these cases without lumbar drainage as in those given repeated spinal punctures.

Animal experiments. The results of studies on 7 dogs including the amount of blood introduced into the subarachnoid space and the amount recovered after various intervals, in the total cerebrospinal fluid, are summarized in Table III.

In 2 of this series of animals only 25 to 29 per cent of the red cells introduced into the subarachnoid space could be recovered in the total specimen of spinal fluid after an interval of from 60 to 90 minutes. Following this there was a fairly regular and rapid disappearance of cells until at the end of 7 days 99.8 had been

[1]For this study fluids were considered clear when the count became 500 red blood cells per cubic millimeter or less. At such a high dilution (1:10,000 of whole blood) the entire subarachnoid space and ventricular system would contain only 0.015 cubic centimeters or two-tenths of a drop of blood. Moreover, if it is attempted to continue punctures beyond this point until the number of red cells is literally zero, the slightest trauma from the puncture needle could easily introduce the negligibly small fraction of a drop of blood required to vitiate all value of further counts. This source of error had to be as carefully guarded against as possible in these determinations but, if present, it could only prolong the period required for the fluid to clear, causing an error "on the safe side" in demonstrating the rapidity with which cells disappear.

TABLE III

Dog No.	Blood count (million cells per c.mm.)	C.cm. of blood injected	Interval of time before drainage of all cerebrospinal fluid	C.cm. of cerebrospinal fluid obtained	Cerebrospinal fluid count (red cells per c.mm.)	Total number of cells introduced ($\times 10^6$)	Total number of cells recovered ($\times 10^6$)	Percentage of injected blood recovered in spinal fluid	Percentage of injected blood which disappeared spontaneously
1	7.5	2.0	1 hr.	8.5	510,000	15,000	4,300	29	71
2	8.0	2.0	1½ hr.	10.0	400,000	16,000	4,000	25	72
3	5.2	2.0	20 hr.	20.0	72,000	10,400	1,440	14	86
4	6.3	2.0	48 hr.	9.0	87,000	12,600	783	6	94
5	7.0	2.0	3 days	9.0	4,700	14,000	42	0.3+	99+
6	6.9	2.0	5 days	10.5	21,000	13,800	220	2—	98+
7	6.3	2.0	7 days	9.0	2,900	12,600	26	0.2	99.8

spontaneously eliminated. A curve (Fig. 3) representing graphically this daily diminution in red cells shows a striking resemblance to curves plotted from daily cell counts on the spinal fluid of human cases of subarachnoid hæmorrhage (Figs. 1 and 2).

COMMENTS

In each case treated by repeated lumbar puncture and the withdrawal of as much cerebrospinal fluid as seemed safe, the amount of blood eliminated divided by the estimated amount initially extravasated gave a fraction ranging in value from one-tenth to one-fifth. The numerator of the fraction may be regarded as an accurate approximation since it was determined from actual cell counts and the measured volume of fluid obtained. On the other hand the denominator is much too small. This is true because the lumbar sample from which the free blood in the total cerebrospinal fluid is calculated contains a much smaller concentration of cells than the fluid near the site of hæmorrhage. Sachs et al have commented on the slow and uneven diffusion which occurs in the spinal fluid. The cells freely suspended in the cerebrospinal fluid throughout the entire subarachnoid space represent only a fraction of those extravasated since many are promptly bound in a clot or entangled in the meshes of the arachnoid trabeculæ.

A rough idea of the factor by which this denominator should be multiplied to get a truer estimate of the total blood in suspension was obtained experimentally in dog 1 of the animal series. In this animal the cerebrospinal fluid was all withdrawn 20 hours after a known quantity of blood was introduced into the subarachnoid space. This interval should allow for maximal diffusion of cells to the lumbar region. The first 40 per cent of the fluid obtained was collected separately and may be assumed to be comparable to the lumbar samples dealt with in human cases. The probable error in this assumption is clearly on the side of minimizing the difference between the spinal specimen and the total fluid since never can so much as 40 per cent of the cerebrospinal fluid be obtained without displacing some of it with air. In this animal the first 40 per cent of fluid contained 21,000 red blood cells per cubic millimeter whereas the total specimen contained 72,000.

A general impression of the share of extravasated blood which is soon fixed and cannot be recovered even if all the cerebrospinal fluid is withdrawn, was obtained experimentally in dogs 2 and 3. In dog 2 only 29 per cent of the blood introduced was found in the fluid 1 hour later and in dog 3 only 25 per cent after 90 minutes. In dog 1 then, the total fluid contained in suspension about 3.5 times as many cells as might be estimated from the lumbar specimen and in dogs 2 and 3 the total blood free in the cerebrospinal fluid represented only 25 to 29 per cent of that originally introduced. In these animals the cell count in the spinal sample of fluid might be multiplied by about twelve and a truer estimate of the subarachnoid blood obtained. It is fair to assume from these experiments that in human cases the estimate of total subarachnoid blood from the

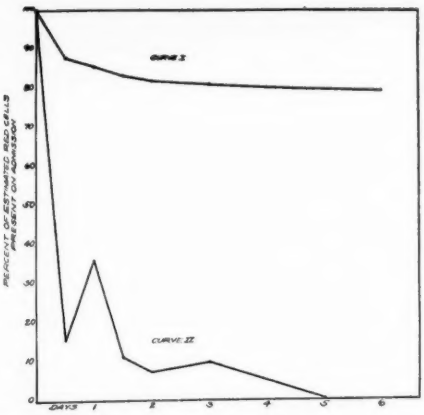

Fig. 1. Typical curves showing the futility of repeated lumbar punctures in eliminating blood from the cerebrospinal fluid in a case of extensive traumatic subarachnoid hæmorrhage. Case N. M. Curve I represents the elimination of red blood cells from the cerebrospinal fluid accomplished by repeated lumbar punctures. Curve II represents the actual disappearance of red blood cells as shown by cell counts on each specimen of fluid. The enormous discrepancy between the two curves represents spontaneous clearing of the cerebrospinal fluid.

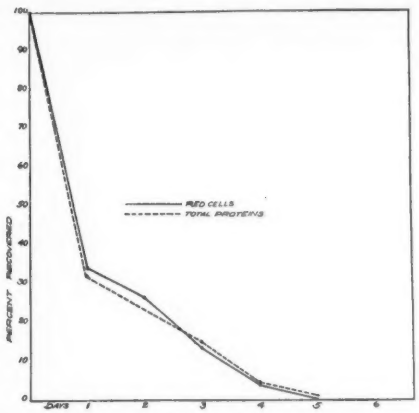

Fig. 2. Curves showing the rapid spontaneous disappearance of blood cells and excess proteins from the cerebrospinal fluid in a case of extensive traumatic subarachnoid hæmorrhage. Case J. K. The solid line curve represents the disappearance of red blood cells from the cerebrospinal fluid as shown by cell counts on the fluid obtained by daily small diagnostic lumbar punctures. The broken line curve represents the elimination of proteins. In 5 days the red cells were reduced from 800,000 to 300 per cubic millimeter and the proteins dropped from 3986 to 48 milligrams per cent.

lumbar sample of fluid is likewise many times too small.[1]

In the second group of cases in which the fluid withdrawn was always limited to from 1 to 5 cubic centimeters, the spinal fluid was clear in the usual 4 to 6 day interval required in the previous group of cases treated with more extensive fluid withdrawals. In 2 cases of this series the protein content of each specimen of fluid was determined. In each instance the spontaneous elimination of excess proteins was strikingly parallel with red cell disappearance, normal values being established within 6 days in each case (Fig. 2).

Each one of the multiple punctures in Group I was performed with a large needle in the hope that spinal fluid leakage would continue through the puncture openings in the dura. Yet the rate of clearing was just as rapid in Group II where the needle used was very small. The negligible importance of continuous fluid leakage is further emphasized by the fact that the rate was still unchanged in

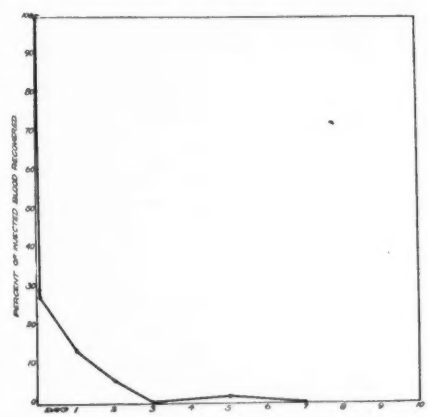

Fig. 3. A composite curve showing the rate of cerebrospinal fluid clearance in a series of dogs in which all of the cerebrospinal fluid was withdrawn at various intervals following the introduction of measured amounts of blood into the subarachnoid space.

[1]This is clearly confirmed by cell counts on the spinal fluid of postoperative cases as illustrated by the following case: D.S., the day following an extensive cortical exploration with the removal of a large scarred area of cortex was found to have 21,500 red blood cells per cubic millimeter in the spinal fluid. Assuming that the lumbar specimen was a true sample and that he had a total of 150 cubic centimeters of cerebrospinal fluid the total blood would be computed to be about 0.6 cubic centimeters or only 9 drops. There is no means of measuring the actual blood introduced by such an operation but any neurosurgeon would at once agree that it would amount to at least several centimeters with the most perfect hæmostasis obtainable.

the 2 cases in which blood elimination was left wholly to spontaneous processes.

To Essick, Weed, Woolard, and Kubie and Schultz we owe a great deal of information regarding the phagocytosis of particulate matter (e.g., carbon particles, trypan blue granules, and red cells) within the subarachnoid space. These workers have demonstrated an active physiological mechanism for the spontaneous clearing of cerebrospinal fluid but in each instance their attention was confined to the origin, character, and activity of phagocytic cells. No quantitative data were obtained therefore regarding the rate of red cell destruction following hæmorrhage or the introduction of known amounts of normal blood.

A day following the introduction of blood in animals of the present series, polymorphonuclear leucocytes appeared in considerable numbers. In 3 days lymphocytes and monocytes were predominant. In 5 days, when only 0.3 per cent of the injected blood remained in the fluid, numerous mononuclear phagocytes were seen engorged with red cell débris which stained heavily with special iron stains. Their abundance was sufficient to indicate strongly that their activity may play a major part in cerebrospinal fluid clearance.

SUMMARY

Blood disappears within 5 or 6 days from the spinal fluid. This period is not influenced by the use of repeated lumbar punctures. Xanthochromatin which makes its gross appearance usually on the second or third day following a subarachnoid hæmorrhage is entirely absent or reduced to a faint trace in 6 days with or without lumbar punctures. The spinal fluid obtained always represents a high dilution of blood and only a small fraction of the total fluid can be removed at one time with safety. Therefore the amount of blood eliminated by lumbar drainage is always amazingly small. In no case studied in the present investigation was more than 10 drops of whole blood removed by an entire series of punctures.

The rate at which blood bearing fluid can be withdrawn from the subarachnoid space necessarily is limited to the rate of secretion of fresh fluid. This is far too slow to rival the rapid spontaneous elimination of red cells so that only a negligible fraction of subarachnoid blood can be removed by repeated withdrawal of spinal fluid by the time fluid clearance takes place.

Lumbar punctures should be used in traumatic cases for diagnosis and reducing abnormal pressure, but are entirely futile as a means of hastening the disappearance of blood from the cerebrospinal fluid.

I gratefully acknowledge my indebtedness to Dr. William Cone for generous help and advice in the present study.

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CARBON DIOXIDE, THE GASEOUS ANÆSTHETICS, AND THE ADVANTAGES OF REBREATHING METHODS OF THEIR ADMINISTRATION

JAMES G. POE, M.D., DALLAS, TEXAS
Anæsthesiologist, Baylor University Hospital

CARBON dioxide, instead of being only a waste product to be exhaled through the lungs, and a factor in the acidbase balance, plays the rôle of a respiratory stimulant. It regulates the heart, affecting both the rate and rhythm and indirectly the vascular system sustaining the blood pressure. It also maintains peristalsis of the alimentary tract, affects the mental equilibrium, and promotes systemic oxidation by increasing the dissociation of oxygen from the hæmoglobin of the blood. Thus the rôle it plays in supporting these important bodily functions makes it about equal in importance to the supply of oxygen, and indeed, without its stimulating effects upon the respiratory center, normal respiration would be impossible.

If we rebreathe pure oxygen into a bag, hyperpnœa soon occurs from the carbon dioxide accumulated therein, thus proving that oxygen want was not the cause of the excessive breathing.

If we voluntarily breathe fast and deeply for several minutes, thus eliminating carbon dioxide from the system, the desire to breathe will be suspended, even until cyanosis may appear, and also fatal apnœa may result. Forced artificial respiration performed vigorously on animals for 15 to 20 minutes, may produce a fatal apnœa from the acapnia thus induced, and after 8 or 9 minutes death usually results from lack of oxygen.

During ether induction when associated with prolonged excitement and hyperpnœa, dogs will often die from apnœa when anæsthesia is completed, there being an insufficient amount of carbon dioxide remaining in the system to stimulate the anæsthetized respiratory center.

Excessive pain from injuries through inducing hyperpnœa and acapnia may result in fatal apnœa when the pain is relieved by open ether anæsthesia, there being no means thus afforded of conserving the carbon dioxide in the system. To offset this danger in those that were severely injured, the ancients partly smothered their patients.

The importance of carbon dioxide and its many vital functions requires that it shall be constant in quantity in the system; hence we find in each individual that there is practically no variation from day to day under normal circumstances.

The alveolar air contains as an average about 5½ volumes per cent of carbon dioxide. Normal respiration does not disturb the relative proportion of the gaseous contents of the alveolar air, as only about 350 cubic centimeters of the tidal air reaches the stationary alveolar air and then intermixes with the latter by diffusion, and thus is normal tranquil respiration maintained, and also the other important functions performed in a regular manner. So delicate is this regulatory mechanism of the respiration performed that even the thought of it disturbs it in an individual, as we cannot breathe regularly if we give it our attention.

If carbon dioxide is added to the inspired air by rebreathing or otherwise, or it is exhaled into the lungs from the blood more freely than normal, as during muscular exercise, respiratory stimulation at once occurs. If 4 or 5 per cent of carbon dioxide is added to the inspired air, or if 0.2 per cent is added to the constant alveolar air, the respiratory efforts will be stimulated to double the normal volume of ventilation. If pure oxygen is breathed instead of air, practically no change in the respiration occurs, and furthermore, if the hæmoglobin of the blood is normally saturated, the corpuscles cannot take any more of the oxygen, and only a small quantity of it can be added to the blood by being dissolved in the plasma when some pressure is applied. Therefore, hyperpnœa depletes the

system of carbon dioxide but does not correspondingly add to the oxygen supply.

When air with less than the normal amount of oxygen in it is inspired, respiration is very little affected until an acidosis from anoxæmia develops to a degree that is capable of stimulating the respiratory center, in conjunction with the carbon dioxide that is present in the system. Cheyne-Stokes breathing is thus engendered.

Because of its power to stimulate respiration, one of the outstanding advantages of carbon dioxide in the administration of inhalation anæsthesia is the active control of respiration it affords, by which means we can hasten the induction of anæsthesia and also the elimination of same, especially of ether, through the increased rate and depth of respiration. The carbon dioxide may be obtained either by rebreathing or from supply tanks.

The most successful use of carbon dioxide requires closed methods of administration and it then partakes of all the advantages of the latter, among which may be mentioned the use of the gaseous anæsthetic agents, the ability to use oxygen in the most advantageous manner, and also the use of ether vapor in the most efficient way and with the least harmful effects. Therefore, the use of carbon dioxide is so intimately associated with closed methods of administration and rebreathing that all their combined advantages may be included in the discussion of the subject.

The advent of the use of the pleasant non-irritant gaseous anæsthetic agents with oxygen and carbon dioxide with the closed method of administration marks a new era in inhalation anæsthesia. Pleasant gas inductions followed with almost immediate recoveries after operations with little or no nausea or discomfort, effectively remove the dread of general anæsthesia, so that people more readily submit to operative measures, thereby greatly enhancing the application of surgery, and materially adding to the efficiency and safety of operative measures.

For the past 14 years all patients receiving general anæsthesia in Baylor University Hospital, private or charity, except tiny infants, have had gas inductions, so that the dread of anæsthesia is almost a thing of the past in our hospital, and I am happy to say this method now prevails in all Dallas hospitals.

With open ether administration we have practically no control of respiration, and the conservation of carbon dioxide is limited to the amount only that may lodge in the mask to be reinhaled, an amount often very insufficient; hence slow and shallow respiration with delayed induction, often with excitement, hyperpnœa with acapnia and troublesome apnœa is the common result. Robust individuals and alcoholics are often very difficult to anæsthetize with open ether, and aside from the discomfort involved, excitement with struggling may result in increased blood pressure, also increased intrathoracic and intracranial pressure to an extent that may result in serious damage, as œdema of the brain, apoplexy, etc.

Nitrous oxide gas oxygen inductions eliminate these dangers and discomforts so completely that open ether inductions are hardly justifiable, even though some form of ether administration is to follow during the operation.

After nitrous oxide gas oxygen inductions we use insufflation of ether, vapor, and air for tonsillectomies, operations for cleft palate, harelip, mastoids, and like operations, and operations on infants. This group of 2,754 cases during the past 41 months comprises most all of our ether anæsthetics. All abdominal and other major operations, except a few with local and spinal anæsthesia, are performed under ethylene-oxygen anæsthesia, which is supplemented in about 50 per cent of the cases with a small amount of ether combined with the gases, 1 ounce of ether being the average amount used.

Ethylene has been thus used since October, 1923, and nitrous oxide gas oxygen with ether supplementary for 4 years prior to beginning the use of ethylene. In this manner we have been able to avoid ether saturation as occurs with the open method. Given in this manner with the gases, it is so readily eliminated that most patients are able to talk before getting back to their beds, and vomiting seldom occurs after the patient is conscious. Ether thus quickly eliminated, has

little or no harmful effects on the blood and tissues. When used early in the operation for relaxation, patients are often unaware that ether has been used with the gases.

The special effectiveness of relatively small amounts of ether and the rapid recovery from it when administered by the closed method is well recognized. It has, therefore, a great advantage over ether anæsthesia by the open method.

The apparent simplicity of open methods, with a small mask being the only apparatus required for the administration, and through the lack of a sufficient number of anæsthetists properly trained to use closed methods, it appears that open ether anæsthesia must unfortunately still be the dependence, especially in the smaller hospitals, for some time to come. Some surgeons still prefer it, however, as they are accustomed to this type of anæsthesia and relaxation.

Factors that tend to prevent acapnia and resultant apnœa with the so called open method are: (a) It is not strictly open, for the mask when covered with towels, etc., retains the latter portion of the air exhaled and this air especially rich in carbon dioxide is inhaled again and thus a degree of rebreathing is afforded that in most cases is quite sufficient. (b) Morphia premedication prevents overstimulation of respiration as from pain, etc. and (c) often a continuous partially obstructed respiration, so that the free elimination of carbon dioxide is prevented. (d) The brevity of the operation, together with the added stimulating effects of ether on the respiration, all act as preventives of apnœa and shallow breathing, the most common and troublesome features of the open method of administration.

In the administration of ether, if the different stages of narcosis (as now taught) are observed and the depth of the anæsthesia is varied to meet the requirements of each operation and as the technique will permit, much will be accomplished in conserving the vitality of the patient, and in preventing unnecessary overanæsthetizing. Anæsthesia sufficiently deep for an intra-abdominal operation might prove fatal in the case of a very sick mastoid patient in whom only the primary stage is required.

When acapnia with limited respiration develops, a rubber tube from the carbon dioxide tank may be placed under the open mask and a small amount of carbon dioxide liberated to be inhaled with only two or three breaths. Respiration at once becomes increased in rate and depth, and a threatened period of apnœa or retching may be averted. The respiration also improves generally, induction may be hastened and later ether may be readily eliminated.

Other special advantages of carbon dioxide and complete rebreathing methods are that the use of ethylene as an anæsthetic is rendered safe from static ignition. The cautery also can be used with safety for the amount of ethylene escaping into the operating room is restricted, thus differing materially from the fractional rebreathing method in which a portion of each exhalation is discharged into the room. The full deep breathing maintained by carbon dioxide and rebreathing throughout the operation lessens the incidence of postoperative pulmonary complications and promotes full oxidation. Furthermore, this method permits of the use of morphia, sodium amytal, and other useful narcotics as preoperative medication without the danger of respiratory depression that might otherwise occur and render their use hazardous. Without premedication with morphia or other narcotics to depress the respiratory center, rebreathing with resultant hypercapnia may overexercise breathing. The bag must then be occasionally partially emptied and refilled with fresh gases to relieve the hyperpnœa.

As special factors safeguarding ethylene from ignition from the cautery, static electricity, etc., I will again refer to complete rebreathing, complete except for a degree of leakage that slowly occurs and requires the addition of fresh gases from time to time, thus effectively preventing overrebreathing. The leakage is slow enough, however, effectively to prevent the ethylene from accumulating in an unsafe and detectable quantity in the operating room. With proper room ventilation and by further safeguarding by the use of a wet towel draped over the facepiece, we use the cautery for hæmorrhoids, and such operations, as freely as desired.

Further precautions we sometimes use are: to direct a current of air across the patient with a buzz fan, and to give nitrous oxide gas temporarily while the cautery is being used.

Complete rebreathing in the manner just described affords the accumulation of humidity and carbon dioxide; the quantities of the former being sufficient to exclude static electricity (65 per cent or over), and of the latter to limit combustion (2½ per cent carbon dioxide in the air will extinguish a lighted candle—the average quantity in the rebreathing bag being 5.53 per cent).

The apparatus we use is simple consisting practically of a face-piece, rebreathing bag, and a tank carrier, and because of its simple construction is especially safe since there are no compartments, bags, and large tubing in which the dry mixed gases which flow directly from the supply tanks, unaffected by rebreathing, are contained, and in which the gases would be endangered from static electricity that could very easily be engendered from within.

We use no grounding of either the apparatus or the patient, as a grounded apparatus is endangered by the possibility of static discharges from the patient or other surrounding objects, and the grounded patient is endangered by possible contact with the house current; furthermore, groundings have proved inefficient against static ignitions as reported in the experiences of others.

We have no measuring devices with special mechanics to complicate the administration. The process of administering the anæsthetic is individualized, hand made, so to speak; the patient is the only guide. The technique is therefore greatly simplified, as the anæsthetist can reach to each tank for the gas he desires, and ether is added when needed through the sightfeed drop cup attached.

This type of rebreathing was originated by Dr. Gatch of Baltimore many years ago, and but for the confusion brought about through complicated apparatus, nitrous oxide gas would have been in as general use as has ether since 1868, when Dr. Andrews discovered that if used with oxygen instead of air a continuous anæsthetic could be had.

To insure the safety of ethylene from static ignition, our practice is to induce anæsthesia with nitrous oxide gas oxygen, nitrous oxide gas being non-inflammable. It is rebreathed from the beginning and ethylene or ether is added, as the case may be, after consciousness is lost, this usually requiring 2 or 3 minutes. The relative humidity in the bag long before this time is one hundred per cent, as each breath adds nearly 10 per cent humidity into the rebreathing bag, as shown by hygroscopic tests. Sixty-five per cent relative humidity eliminates static electricity, as quoted recently by the bureau of mines. Induction may be safely accomplished with ethylene by rebreathing it sufficiently before adding oxygen.

If we consider the fire extinguishing characteristics of carbon dioxide and the positive eliminating effects of humidity on static electricity, the safety from static ignition of ethylene or ether as now combined with nitrous oxide gas oxygen is assured, and depends upon definite physical conditions, and not upon theory, or the possibility of imperfect groundings such as a chain dangling on metal strips within the floor. Thus may be understood our reasons for the extensive use of ethylene: in over 40,000 ethylene anæsthesias since October, 1923 (as per estimate) we have experienced no ignition of any kind; and 9,259 to be exact, in the last 41 months, earlier records not being at hand. Other surrounding hospitals in Texas and adjoining states that have used ethylene and ether by the same method, can add many thousands more to the list, without a static ignition occurring to mar their excellent service.

We do not use ethylene for the relief of intermittent labor pains, as a safe amount of humidity might not be preserved and the ethylene thus become ignited by a static discharge when the face-piece is being either removed or replaced on the face.

We use nitrous oxide for this intermittent service, and ethylene only where a continuous anæsthetic is to be used, as when the head is being delivered, or for perineal repairs, etc., after nitrous oxide induction.

Fractional rebreathing may not retain sufficient humidity to be dependable to render ethylene safe, hence we avoid the use of this method altogether in the hospital.

The incidence of postanæsthetic pulmonary complications is comparatively low in our service, as may be estimated from a recent study of 1,032 appendectomies occurring in Baylor University Hospital from June 1, 1930, to February 1, 1933. This study was conducted by Drs. Holden and Dathey, under the direction of Dr. J. Shirley Sweeney. In this series there was only one pulmonary complication, this occurring in a man 30 years of age who had an acute suppurative gangrenous appendix. His condition was fairly good after the operation; bronchopneumonia developed the second day, proving fatal within 24 hours. Twenty-eight per cent of these appendectomies were incidental to other major surgery, the majority of the operations being for some female pelvic conditions, thus adding to their gravity and chances of complications. With only 8 postoperative pulmonary complications and one death reported by the house surgeon during the year previous to July 1, 1933, and none since that date to the present time (November 20, 1933), I feel justified in saying that these complications are a minor problem with us, as compared with many results in other hospitals, especially in the northern and eastern states. Probably climatic conditions may play a part, as our atmosphere is usually free of dust and smoke, but I believe that the full deep respiration which we maintain throughout the operation, and the relatively complete rebreathing, with added carbon dioxide when necessary, and with ethylene as the principal anæsthetic agent, with a minimal amount of ether as a supplement, are the main preventive factors. We often add carbon dioxide with an over amount of oxygen at the end of an anæsthetic, to insure full oxygenation and inflation of the lungs, especially if the respiration has been somewhat unsatisfactory during the operation.

In a recent investigation of a limited series of cases by our house surgeon, Dr. Jack Kerr, it was found by chemical analysis that the average amount of carbon dioxide in the rebreathing bag during anæsthesia was 5.53 per cent, and that the average reduction in vital capacity after major operations performed under general anæsthetics ranging from 20 minutes to 1 hour 40 minutes, was 26 per cent, thus showing no special excess of carbon dioxide from rebreathing, and a well retained vital capacity.

Carbon dioxide combined with oxygen is used extensively in some hospitals to hasten the elimination of ether after the patient is returned to bed, special apparatus being devised so that the nurse may use it at intervals in the room. This can serve a useful purpose when ether by the open method of administration is used; however, we have no need for this with our light methods of giving ether anæsthesia. Except for the use of morphia premedication, we would have far more trouble keeping the patient on the carrier while getting him to the bed, than to eliminate his anæsthetic after getting him there. To illustrate: A man recently had a herniotomy performed. The anæsthetics used were ethylene and oxygen and the anæsthesia lasted 30 minutes. The surgeon dressed immediately and went by the patient's room to see him and found him reading the morning newspaper. Another man who had had an extensive intra-abdominal operation under ethylene-oxygen anæsthesia lasting 2 hours and 35 minutes, recovered immediately on the operating table and said he felt fine. Even with the addition of some ether in these cases, recovery occurs by the time they reach their bed, or very soon thereafter. Sometimes a little ether is added to prevent an immediate awakening that may be accompanied with pain or discomfort and restlessness.

The economic feature of complete rebreathing methods of administration is readily apparent. The anæsthetic gases do not change any by being inhaled, and to discharge a part of each exhalation into the air of the room is needless waste, and also endangers ignition, if ethylene is being used. The oxygen is used by the patient and must be replenished as needed. Moisture accumulates to exclude static electricity, and carbon dioxide accumulates sufficiently to induce full and free respiration, thus overcoming the respiratory depression induced by morphia or other necessary pre-anæsthetic narcotics given. Then through leakage from the rebreathing bag with the other gases that must be replenished

from time to time, an over quantity of carbon dioxide is effectively prevented from occurring, and thus do we obtain, without the cost and the complicated apparatus that this method requires, approximately the same economic results as with soda lime absorption. The average cost of our inhalation anæsthetics during the past 41 months has been one dollar and two cents each. This also includes the upkeep, and apparatus supplies purchased. During September just passed this average cost was 69 cents, during October 58 cents.

Boothby stated that 95 per cent of all emergencies occurring during the course of anæsthesia are due to respiratory obstruction. The rigidity with which the mask or facepiece must be strapped on to prevent any possible leakage, would greatly endanger the patient should vomiting occur. Through excitement small particles of the soda lime might be inhaled with a quick change of position by the patient, and respiration may be overly retarded by breathing through the soda lime and the valves of the apparatus and be exhausting to the patient. The excessive heat generated by the chemical change in the soda lime which may reach as high as the boiling point (212 degrees F.) under certain conditions, must also have due consideration as other chemical changes may occur, or the patient's tissues become injured thereby.

Considering the value of full deep breathing as a preventative of pulmonary postoperative complications, the necessity of carbon dioxide to maintain proper respiration with narcotic premedication, the quiet shallow breathing characteristic of this carbon dioxide absorption method, may prove to be detrimental in many cases. Carbon dioxide with its many important functions is less harmful in a moderate excess in the body than is a deficiency of same.

With full and free involuntary respiration, the occasional sigh, and a pink patient who awakes almost immediately after the administration ceases, we may safely conclude that rebreathing is not overdone with this method that we have used so extensively during the past 14 years.

CONCLUSIONS

1. Open ether inductions of anæsthesia should be dispensed with (except in tiny infants), because of the dangers of acapnia, apnœa, excitement, and struggling. It perpetuates the dread of anæsthesia, and thus materially hinders the progress of surgery.

2. The induction of anæsthesia with nitrous oxide gas oxygen, changing to ethylene after consciousness is lost, with or without the addition of ether as may be required, and with proper narcotic premedication, is the safest, and most useful of all general anæsthetics known.

3. With the maintenance of sufficient humidity in the bag which is not difficult, as shown herein, ethylene is safe from static ignition, and also is safe regardless of its percentage with oxygen in the moisture filled bag, as proved daily in our service.

4. To discard the use of ethylene in surgery would be analogous to discarding gasoline in present day transportation. Ethylene, however, should be administered only by those well instructed in its use, and as with ether, the anæsthetist should know how properly to safeguard against ignition.

5. Surgeons and dentists should have a working knowledge of anæsthetics. To this end Baylor University medical and dental students are taught by didactic lectures and demonstrations. The hospital internes have a definitely assigned service, administering anæsthetics, both gas and ether, under proper supervision of the anæsthetic staff. We also train a limited number of well qualified graduate nurses, from which we select those for our own hospital anæsthetic service.

6. Modern anæsthesia should be administered only by those who are specially trained in the art.

"PRECANCER" OF THE CERVIX UTERI

Some Pertinent Observations on Its Status[1]

NATHAN FREEDMAN, M.D., M.Sc., Montreal, Canada

DESPITE the intensive research upon the "precancer" state of the cervix uteri, its exact histological definition and diagnosis is still a matter of personal interpretation and bias. Thus a suspicious piece of tissue appears actually cancerous to some and precancerous or abnormally hyperplastic to others. The difficulty lies in the absence of a satisfactory histological explanation justifying the existence of "precancer"; although clinically it is accepted generally that there is such a stage in cancer evolution.

Typical general descriptions of this condition include vague and unscientific statements somewhat as follows:—"Looks like cancer but falls short of it," "suspiciously like cancer," "suspicious," "the cytology is that found in a well developed cancer of the cervix," "mimics cancer perfectly histologically," "one hesitates to call it cancer," etc., etc.

Histological definitions of precancer are more complete, but they do not give a final and positive means of differentiation from incipient cancer. Oertel describes these carcinoid cells in the breast and prostate as follows: "These cells change their morphological and tinctorial characters, assume appearances of altered differentiation with atypical shape and size, and develop disturbed nuclear plasma relations." Stone writes about the altered cervix thus:

> In some cases the amount of proliferation will make a striking feature; in others the atypical quality of the cells—their size, irregular shape, peculiar staining qualities especially the larger size and hyperchromatism of their nuclei, or their loss of polarity—will present such pictures that one feels reasonably certain that a malignant growth is in a developing stage. To many of such areas the term "precancerous" seems to be appropriately applied.

Villard and Montel find the precancerous state in the cervix characterized by "cellular modifications with anarchistic tendencies, that is cellular monstrosities, and abnormal epithelium situated in the flat epithelium outside of the germinative bed." Bonney in a study of precancerous changes in several situations finds a constant loss of elastic tissue, and usually hyaline changes in the collagen, lymphocytic exudate, and fraying of the edges of the epithelium.

Martzloff demonstrates in leucoplakia of the cervix the cytology commonly encountered in a well developed cancer of the cervix (cells irregular in size, shape, and staining reaction, loss of polarity; spindle cells may be found at almost any level, while large polynuclear cells, multinucleolated nuclei, mitotic figures and epithelial whorls may be present). He is rather chary about diagnosing these conditions as cancerous, unless invasion is present; but he does admit that "if the term precancerous is permissible, it might be applied here."

In an illustration of a section Huggins shows an extensive hyperplasia of the stratified squamous epithelium in the repair of a cervical ulcer. He notes "the epithelial tissues have extended for a distance of two or three times further into the stroma of the cervix than happens under normal conditions and present a ragged and irregular border. The cells are more or less atypical and the condition is definitely a precancerous one."

When one comes to study the precancerous stage in adenocarcinoma and columnar-cell carcinoma, there are found poor descriptions of the condition although it is accepted as a factor in the evolution of the final stage of this type of malignancy. Thus Stone presents an illustration of glandular overgrowth in a cervix and comments: "There are glandular hyperplasias which lead to adenoma or adenocarcinoma." Adami and McCrae recognize that there is a difference in degree only and not in kind between the inflammatory or irritative hyperplasia of glandular epithelium, the adenoma, and finally the malignant glandular carcinomata.

[1] The histopathological material in this study, except Figure 15, is part of a thesis submitted in partial fulfilment of requirements for the degree Master of Science in Pathology, McGill University, 1928. Figures 1, 3, and 6 have appeared previously (Freedman, Nathan. Am. J. Obst. & Gynec., 1931, xxi, Jan.).

HISTOPATHOLOGY OF ENDOCERVICITIS

The cervix uteri assumes altered pathological states as a result of various etiological factors, chief of which are the traumas and lacerations of labor with consequent infections. Microscopically, in the early stages of inflammation the most important changes would be hyperplasia and hypertrophy of the cells in lining squamous epithelium and glands, metaplasia of the columnar cells of the columnar epithelium and the glands, and downward growth of the widened epithelium into the stroma. The vasculature becomes engorged and there is evident a zone of lymphocytic cells under the basement membrane and penetrating upward into the cellular epithelium. The lining cells, including those in the glands, at first might show an orderly arrangement and appear hypertrophic and hyperplastic. Later more abnormal changes develop and produce the confusing pictures suggestive of "precancer" or cancer. These stages do not proceed in an orderly progressive fashion as just described, but merge one into the other; thus there might be all grades of inflammation in one and the same cervix, or in one and the same field observed under the microscope.

Briefly, the cells in the aggravated stages of cervicitis might be hypertrophic, vary in size and shape, be multinucleated, show amitosis, hyperchromatism of the nuclei, and an altered nuclear plasma relationship. Some giant cells may be seen, and in some situations the cells penetrate downward into the stroma and overgrow other tissues. Most of these abnormalities are also present in established cancer, yet such affected tissues might be stamped as "precancerous" or "suspicious"; others would label them as cancerous (see Figs. 1 to 14, inclusive).

In the literature the terms "incipient cancer," "beginning cancer," and "precancer" are loosely applied, and in many cases are made to appear synonymous. This conception is wrong, because incipient or beginning cancer can mean only established cancer although in its earliest stage, while "precancer" presumes only the future probability of cancer developing. Not every case of precancer turns into cancer later, as some remain stationary.

DIFFICULTIES IN THE FORMULATION OF "PRECANCER" CRITERIA

A glance at the recognized criteria of established cancer does not clarify the situation as to the differential diagnosis of "precancer." Ewing presents the following attributes of cancer with the qualification that "any one or all of which may be present": (1) abnormal cellular overgrowth; (2) atypical qualities of the cells (increased nuclear content of nucleus, alterations in size of cells, hyperplasia, excessive or atypical mitosis, degenerative nuclear and cytoplasmic changes); (3) heterotopia; (4) local invasive or destructive properties; (5) desmoplastic properties; (6) loss of polarity; (7) metastases.

The most accepted ideas of *incipient* cancer seem to lay stress on the abnormal cell morphology. Thus Schauenstein, Schottlaender, Ewing, and Rubin find that the characteristics of incipient carcinoma are as follows: (1) irregular arrangement of cells; (2) loss of cell boundary; (3) abnormally close juxtaposition of cells; (4) changes in chromatin network; (5) changes in protoplasm toward stains (eosinophilia).

As mentioned above cancer can be diagnosticated microscopically even when only one of Ewing's criteria are present; and yet that criterion may be the feature of a tissue that is still in the *precancerous stage*. There seems to be an intermingling and common basis in some of the criteria of precancer and cancer, although of course the histological structures of the two conditions are different.

The most frequent findings common to both precancer and cancer are in order of importance: (1) atypical cellular changes; (2) abnormal cellular overgrowth; (3) heterotopia; (4) loss of polarity.

When one studies any single accepted criterion of cancer there is a doubt left as to the minimum amount of abnormality that must be present to eliminate the precancer stage in a suspicious piece of tissue. Theoretically if one finds the same type of cellular changes in the two stages of precancer and cancer, all precancers should be labelled as actually cancerous even if only one cancer-like cell is demonstrated histologically. Practically, of course, this is not so.

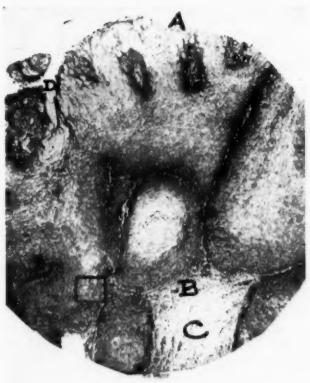

Fig. 1. Section of cervix of patient aged 34 years, showing papilloma. Very low power. Note the extraordinary broadening of the squamous layers, the epithelium being about six times as wide as the normal lining. *A*, Upper border of squamous epithelium; *B*, lower border; *C*, overshadowed stroma; *D*, hornification.

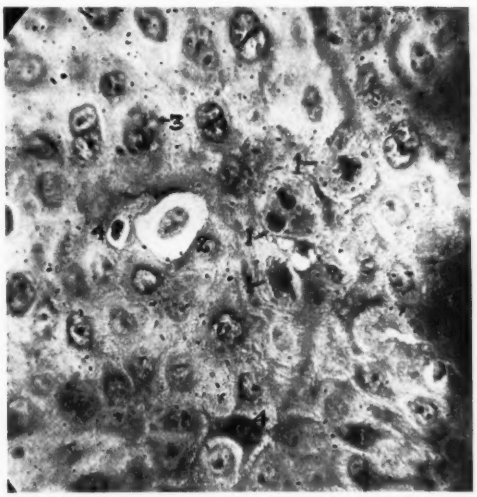

Fig. 2. Oil immersion study of blocked area in Figure 1. Abnormal cytology of the squamous epithelium. *1*, Mitotic figures; *2*, giant cell; *3*, multinucleated cell; *4*, hyperchromatic cell. Note the fairly normal cells interspersed between the cancer-like cells.

Lacking an absolute and unequivocal histological dividing point between the two conditions, we are forced from the evidence at hand to believe that cancer is an intensification or follow-up stage of precancer. One should not believe that an increased number of suspicious attributes in a piece of tissue makes that tissue cancerous, just as typhoid is diagnosticated from a number of relatively mild symptoms. This would seem to be the policy of some observers, however.

The lack of a formal and precise description of precancer has caused certain observers to doubt the possibility of diagnosing this stage microscopically, and thus they lean toward the idea of a tissue being either actually cancerous when any of the attributes of cancer are present, or non-cancerous otherwise. Thus Frank doubts the possibility of diagnosing early cancer in "conditions which lacking as we do absolute histological criteria of early malignancy, may as well prove to be harmless epithelial proliferation." Keller and Van de Vyver agree with Schiller (17) that it is not possible to diagnosticate microscopically a precancer state, and that many so called precancers are really established cancers. Robert Meyer believes that as soon as a tissue possesses a single criterion of malignancy that tissue is no longer precancerous. He would call precancerous those cellular changes which take place in the interior of the cell and which are not visible under the microscope and cannot give a special histological morphology.

EARLIEST CANCER DIAGNOSIS IN ITS RELATION TO "PRECANCER"

Are cellular changes alone sufficient to establish carcinoma diagnosis? Several investigators quoted by Stone have observed in the uterus that a certain type of early cancer spreads superficially over wide areas before showing marked invasive features. Broders emphasizes that carcinoma or cancer, regardless of etiology, is a primary disease of epithelial cells, and that all other phases and sequelæ, although of great importance, are in reality of secondary nature. Further on in his paper he notes that "the diagnosis of carcinoma *in situ* as of carcinoma in general, is based chiefly on altered cellular characteristics in contradistinction to the cellular situation. The nuclei as compared with those of normal cells, have an increased avidity for the basophilic dyes, are usually increased in size both actually and in relation to the cytoplasm, are frequently irregular, are not infrequently

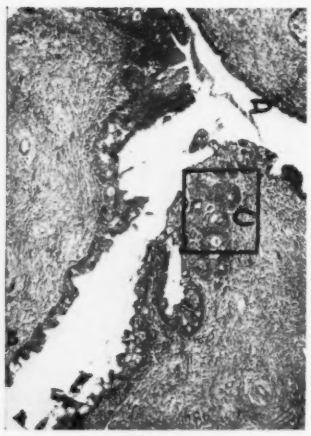

Fig. 3.

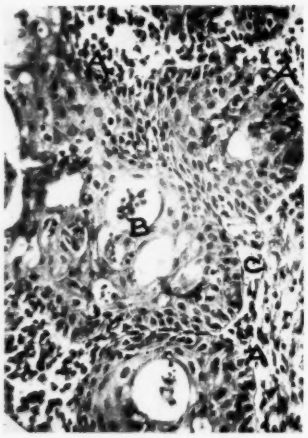

Fig. 4.

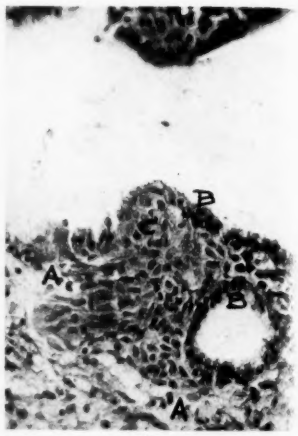

Fig. 5.

Fig. 3. Section of cervix of woman aged 40 years. Low power. Excessive atypical overgrowth of new squamous cells along the walls of a large duct, penetrating into glands and overcoming them; and also dipping down into the stroma. At *A* and *B* a view is given of the beginning of the process with new cells piling up under the columnar epithelium normally lining the duct. Further up at *C* is the increasing stratification in glands and stroma. The unaffected duct lining is well shown at *D*.

Fig. 4. High power view of area blocked off in Figure 3. The prickle cells are shown at *A*, the flat desquamating cells at *B*, and the intact basement membrane at *C*. The cells are somewhat modified and are excessive in quantit There is no loss of polarity, and the presence of uniformi in the cells also rules out cancer. Picture is that of a ca cinoid condition.

Fig. 5. Section of cervix in woman aged 40 years. Ne cells of epidermization growing in between two gland The cells are modified in character, only slightly resemblin stratified squamous epithelium; they are loosely arrange and irregular, and there is no basement membrane. *A* rep resents the edge and denotes the absent basement mem brane; *B*, the columnar epithelium lining the glands *C*, the atypical cells. There is too much regularity in thi picture to call it anything but a carcinoid condition.

in a state of atypical or pathological mitosis, and are occasionally observed in groups in the form of tumor giant cells."

He discounts the importance of penetration of the epithelial cells past the basement membrane as a diagnosis of carcinoma, but stresses above all else the type of lining cells even when within the basement membrane confines, as the final arbiter of malignancy. His discussion of characteristic malignant attributes of the cells fits in fairly closely with those changes observed in the severest cases of cervicitis, but which cannot be definitely classed as cancerous by any means. These cellular changes seem to disagree only in a matter of quantity from those in actual cancer (see Figs. 1 to 14, inclusive).

Stone believes that the positive identification of a malignant neoplasm cannot be made histologically until definite destructive capacity is recognized, although paradoxically he points out that a certain type of early cancer spreads superficially over wide areas before showing marked invasive features. Ewing while certain that beginning carcinoma can be diagnosticated from marked cellular changes, believes that there can be no room for doubt if the features of downward growth and heterotopia are added. Rubin does not accept the deep invasion of the neoplastic cervical surface epithelium into well marked inflammatory stroma as pathognomonic for the presence of a carcinomatous process. His conclusion is that "the important criteria of malignancy in these early cases lie not so much in the relation of the cell nests to the stroma, the depth or extent of epithelial invasion, or evidences of surrounding inflammatory changes, as in the intrinsic morphology of the epithelial cells."

Villard and Montel attempt to prove the sequence between inflammation and cancer in a cervix by the appearance on one lip of a hyperplastic metritis, and on the other lip—incipient cancer, point of transition, and the precancer stage. They also note that it is pos-

Fig 6.

Fig. 6. Section of cervix in woman aged 33 years. Epidermization of gland through excessive downgrowth of surface squamous epithelium. At *A*, marked proliferation of squamous cells with rupture through basement membrane.

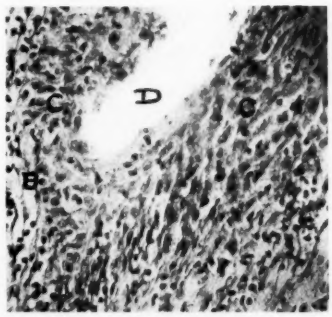

Fig. 7.

Fig. 7. High power view of area blocked off in Figure 6. The stratified squamous cells, *C*, have assumed an abnormal appearance, and there is loss of the basement membrane at *B*. *D* represents the gland lumen. The field is a carcinoid one.

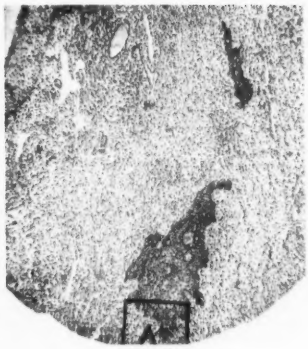

Fig. 8.

Fig. 8. Section of cervix of woman aged 61 years. Pegs of hyperplastic squamous epithelium dipping down deeply into the stroma, *A*.

sible to disclose in the flat epithelium the most extreme beginning of that which can be a cancer, before infiltration in the depth, before any clinical signs of malignancy are apparent.

Keller and Van de Vyver warn against the possibility of a precancerous state being interpreted when a precocious stage of cancer is really present. They are quite certain that the absence of deep penetration cannot be interpreted against the existence of cancer. They believe that many early cancers show nothing but a modification of the superficial epithelial layers without deep penetration, even after serial section study.

The opinion of Lubarsch is that cancer should be diagnosticated only "when one has found sure and clear criteria of destructive growth."

As previously mentioned, Robert Meyer (11, 12) believes that as soon as a tissue possesses a single criterion of malignancy, that tissue is no longer precancerous.

Novak after distinguishing the deep penetration of squamous epithelium in the inflammatory cervices from actual cancer by the fact that in inflammation the invasion of the depths by creepers of squamous epithelium proceeds along the trellis furnished by the inflamed framework, while the penetration of actual cancer is a more ruthless and less orderly one, notes: "After all, however, the differentiation of these inflammatory lesions from very early cancer is based upon the study of the cells themselves rather than upon such differences in general architecture as have been discussed." He would differentiate the benign lesion by the fact that it is only the

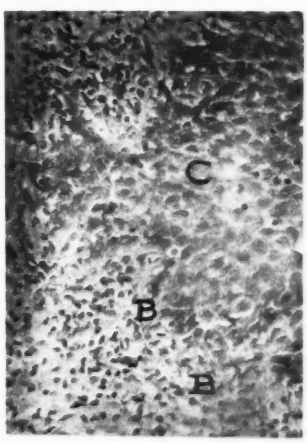

Fig. 9. High power view of blocked area in Figure 8 *B*, Absent basement membrane region; *C*, slightly modified squamous cells. This is a good example of heterotopia in a benign piece of tissue.

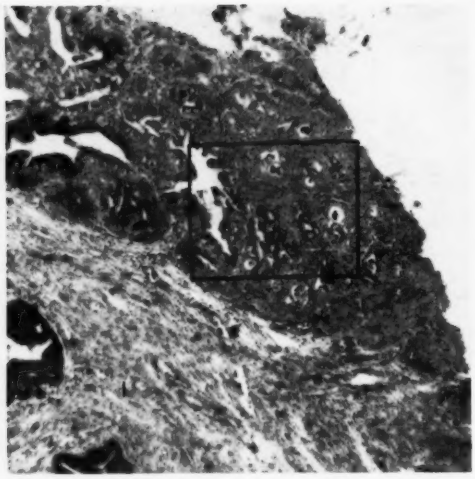

Fig. 10. Low power photomicrograph of cervix. Excessive growth of the stratified squamous epithelium which is arranged in alveolar fashion.

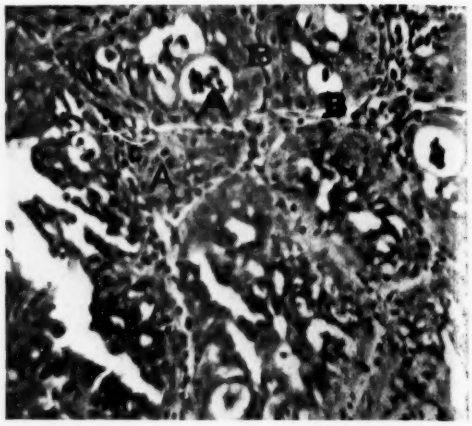

Fig. 11. High power view of blocked region in Figure 10. The alveoli are filled with a basal type of cell, *A*. Basement membranes, *B*, are intact.

basal cells of the epithelium which are arranged perpendicularly to the basement membrane like palisades, while in carcinoma this perpendicularity is often noted in the upper layers as well.

As previously described, Martzloff demonstrates in leucoplakia of the cervix the cytology commonly encountered in a well developed cancer of the cervix. He insists that such a histological picture lacks one anatomical requisite, invasion, to make it a carcinoma.

Schiller (18), in a masterly article on early diagnosis of cancer of the cervix, describes how most of these cancers are separated from the normal tissue by a definite zone of atypical tissue of about the same width as the normal epithelium. This is called the carcinomatous layer, and, according to him, represents the first stage of the development of actual carcinoma. The earliest cervical cancers would be represented by nothing but a layer of altered cells (staining white with Lugol's iodine in contrast to the mahogany brown of the normal cervical tissue); later there would be beginning downgrowth, until finally we would have advanced downgrowth and superficial ulceration in addition to this superficial layer. This carcinomatous layer is diagnosed as cancer solely by its altered cytology, and he points out that "from the old and antiquated point of view carcinoma is diagnosed only when it penetrates deeply." The youngest carcinoma diagnosed by him measured 2 to 3 millimeters in diameter, and presented such cellular changes with no downgrowth or metastases.

The cytology of this carcinomatous layer is described as follows: "Polymorphic and atypical cells, especially as regards the nuclei. Large nuclei may be surrounded by small ones, dark nuclei may be next to light nuclei, and occasionally giant cells may be found with several nuclei in one cell. The great number of nuclei is extraordinary, there being more nuclei than in the healthy epithelium. The regular order as seen in normal epithelium, is absent. In healthy epithelium the number of nuclei diminishes centrifugally from basal layer to the surface, until in the superficial layer only a few shrunken nuclei lying in large cell alveoli are found. In the presence of a carcinomatous layer, however, we find on the surface a great number of dark nuclei lying close to one another. The basal layer is sharply demarcated against the underlying connective tissue and never shows projecting single cells or groups of cells." He notes that occasionally one can see within the *normal* tissue near the borderline, single dark cells which from a morphological point of view are characteristic of carcinoma (see Fig. 15).

He notes also as a characteristic of this carcinomatous epithelium that "the superficial layer, which in normal epithelium consists of large vesicular light cells with small shrunken nuclei or nests of nuclei, is missing. This superficial layer, which is typical in the epithelium of the cervix—normally the epithelium of the cervix does not show parakeratosis—is filled with glycogen as proved by staining."

He describes how Bowen's precancerous dermatoses were originally diagnosed as such because there was no downgrowth and only altered cellular epithelium. Study later revealed that downgrowth would develop in time, so that these dermatoses were really actually cancerous at the time there were only cellular changes present. Schiller dismisses the term "precancerous" as being too ambiguous.

It is interesting to note in some of the sections (Figs. 2, 4, 7, 14) how closely the cells approach in type those found in established cancer. In several cases the cells in certain spots are actually cancerous in appearance.

THE CANCER CELL STRUCTURE IN ITS RELATION TO "PRECANCER"

There does not seem to be any doubt that cancer can be diagnosticated from cell changes alone—even when no other criteria of cancer are present. The cancer cell itself when studied intimately presents definite signs as compared to the normal cell. The nucleus may show an increased chromatin content and abnormal mitosis either in the form of increased or atypical mitosis. The nuclear protoplasmic ratio is altered, the nucleus and nucleolus being increased in size relatively as to the rest of the cell (MacCarty) (see Figs. 15 and 16).

In respect to the significance of mitotic figures, Novak after reminding one that regeneration normally takes place from the basal layer, remarks that mitoses are almost never seen in this layer under normal conditions, or even in inflammatory lesions. According to him they are even more rare in the superficial layers; he has never seen mitoses in the upper strata except in malignancy. Cullen agrees that mitoses in the cervical epithelium, squamous and columnar, occur only in the presence of cancer. He remarks that these nuclear figures are "regularly met with in the epithelium of the body of the uterus, and in cases of hyperplasia of the endometrium nuclear figures are frequently found in the stroma cells of the mucosa."

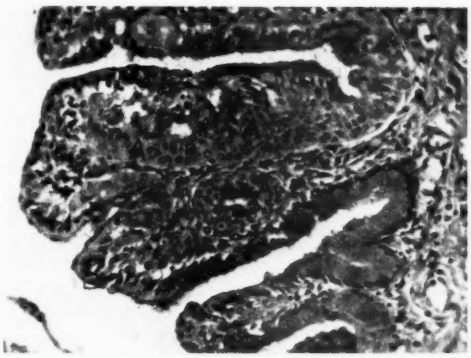

Fig. 12. Section of cervix. High power view. Epidermization into stroma, *A*, under normal columnar lining of glands, *B*. These new cells are basal in type. The whole picture is suggestive of a carcinoid stage.

Martzloff doubts that mitotic figures are pathognomonic of cancer in the cervix; and as previously mentioned he believes that even in the presence of marked cytological abnormalities there can be no definite diagnosis of cancer of the cervix unless the property of invasion is added (see Figs. 1 and 2).

In Figure 2 can be seen three mitotic figures lying closely together and surrounded by many abnormal cells. Cancer diagnosis of this section is nevertheless dismissed on account of the many normal cells in the field, and the lack of general disorganization of the tissue.

DEDUCTIONS

A perusal of the above leaves one with a rather bewildered idea as regards the existence of a precancer state. There seems to be no doubt that the earliest cancers may present only an altered cytology, and that tissues frequently labelled precancerous contain these cells which differ from cancer not so much qualitatively as quantitatively. It is also quite evident that many so called harmless precancers containing these abnormal cells, are in reality definitely cancerous. It is a fact that there is a precancer state, if we assume it to be the phase just short of cancer, which has

Fig. 13. Low power view of gland overrun by an atypical type of squamous epithelium.

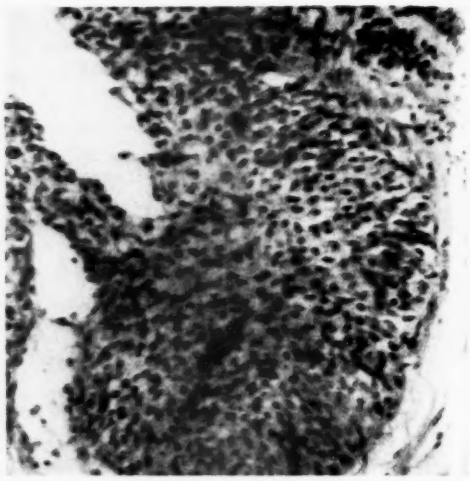

Fig. 14. High power of blocked area. in Figure 13. Carcinoid change.

developed as a result of chronic irritation through the inflammatory and hyperplastic pathological stages. If we exclude from the term "precancerous" those abnormal states which may, but never do, develop into carcinoma, there can be less objection to this much maligned and ill used word.

There is a much better terminology at hand, such as (a) the word "carcinoid" of Borst which does not imply that the suspicious tissue must inexorably go on to cancer formation, (b) the "approach cancer" of Itchikawa, (c) "borderline," (d) "cancer like," (e) "potentially cancerous," (f) "ill defined cancer," and (g) "latent cancer." The best terms are "carcinoid" and "borderline," and the word "carcinoid" probably meets the highest requirements and is the word that is most suitable.

The fact that not all of these carcinoid tissues go on to actual cancer does not detract from their importance in the prevention of cancer, and a guarded attitude should be taken; frequent local examinations with biopsies to ascertain any progress toward malignancy should be undertaken if necessary. This is probably the only way to distinguish those carcinoid conditions that will surely turn into malignancy later.

Clinically we know well that there is a precursory stage in cancer evolution as precancer. Are we then to exclude this stage completely, and to speak of a tissue as either cancerous when it contains the altered cells previously described, or as non-cancerous otherwise? If we accept the theory of the presence of a precancer state, how can we diagnose and orientate it, how can we correlate the parallel findings of abnormal cytology in the two stages of precancer and cancer, and how can we avoid labelling the precancer condition as really cancerous?

To the student of carcinoma of the cervix it seems rather premature and wrong to be forced to diagnose as carcinomatous those sections which present only a few altered cells of the malignant type in an otherwise normal field of cells arranged in an orderly fashion with no loss of polarity.

If we find interspersed between these suspicious cells many other cells which are only slightly altered, and in fact quite normal, i can be reasonably certain that we are dealing with a stage just short of actual cancer (see Figs. 2 and 4, and compare with Figs. 15 and 16).

The fact that we find it impossible to lay down a perfect formula for the precancer

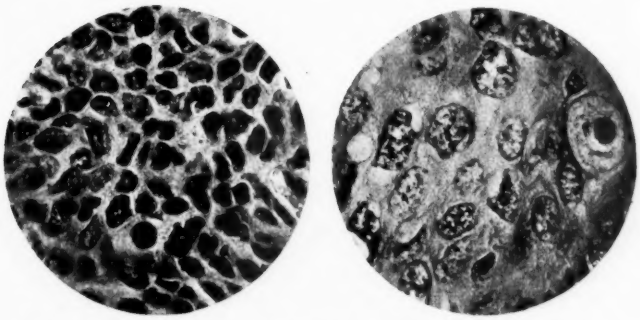

Fig. 15. Type of cells found in the carcinomatous layer. Note how in two separate cases of very early cancer of the cervix the carcinomatous layer shows atypical mitotic figures, atypical nuclei, and cells, and loss of polarity; in short a definite picture of cancer, although there is no deep penetration as yet. The absence of normal type cells is very noticeable. (From Schiller, Surg., Gynec. & Obst., 1933, lvi, 210. (×475).

stage does not preclude its existence. Study of the histogenesis of cancer would prove that there is such a precursory stage, call it by whatever name is desirable.

Vital stains somewhat of the type described by Schiller (18) and Ludford would seem to be an ideal way at the moment to differentiate malignant from non-malignant tissue.

As already described, Schiller paints Lugol's iodine solution over the cervix, and the cancer cells do not assume the stain, remaining white, while the normal tissue becomes stained mahogany brown. Ludford's trypan blue when injected, causes normal cells to be stained in contrast to cancer cells, which remain unstained. The contrast is best seen between normal fibroblasts and sarcoma cells, and normal and malignant mammary cells. Between normal and malignant skin cells, the difference is in degree rather than kind.

Further study is required to orientate those suspicious tissues labelled precancerous by observing if the field would take up differential stains and so provide the diagnosis.

It is interesting to mention that Schiller (18) noted a distinct demarcation between the carcinomatous layer and the normal epithelium. Areas of transition were nowhere to be found, nor were there transitory cells. However, he did see within the *normal* tissue near the borderline single dark cells which from a morphological standpoint are characteristic of carcinomata. It seems logical to assume from the fact that this normal tissue was in close apposition to definitely established carcinoma, and already contained some cancer cells, that it was developing into actual incipient cancer, but at the time of examination was in a precursory stage of evolution (the carcinoid stage). The presence of a few single cancer cells was not sufficient, however, for Schiller to stamp the tissue as cancerous.

It is hard to reconcile the abrupt and sharp separation of cancer from the non-cancerous tissue, if one believes that cancer is a gradual process.

CONCLUSIONS

A histopathological study has been made on sections of precancer of the cervix not so much to describe the condition as to demonstrate the points of relative similarity between it and the earliest cancers—this similarity causing a confusion in diagnosis and a lack of finality about the existence, orientation, or description of precancer. The following conclusions seem warranted:

1. Evidence goes to prove that in the cervix there does exist a precursory stage of cancer, the "precancerous" or preferably the "carcinoid" stage.

2. Cancer is definitely present, and can be diagnosed in the cervix from the altered cytology alone, even when there is not the slightest downgrowth and the basement membrane is intact.

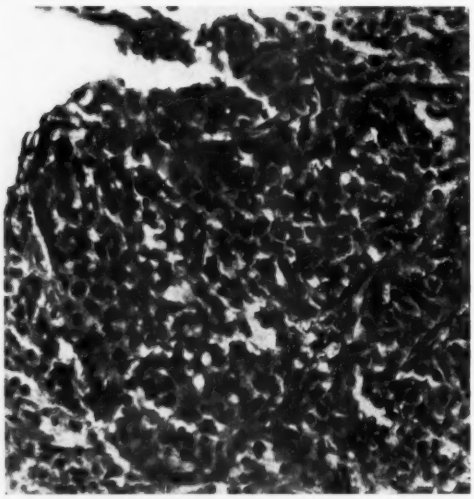

Fig. 16. High power view from a frank case of squamous cell cancer of the cervix, patient aged 35 years. The cells show marked polymorphism and hyperchromatism, with intact basement membrane. The loss of polarity is well shown.

3. Many of the carcinoid conditions which are found in the cervix uteri as a result of chronic irritations, show an altered cytology which is comparable to that found in the genuine cancers; consequently there is much confusion as to the proper diagnosis.

4. Although there are not to be had unassailable scientific histological criteria for carcinoid conditions, there still is a satisfactory means of diagnosis of the condition in the cervix; viz., (a) the general appearance is not suggestive of established cancer; (b) very few actual cancer-like cells are present, and these are single and detached; (c) these altered cells are surrounded and separated by too many normal cells usually very similar in type; (d) there is very little, or no loss of polarity.

5. An attitude in general that cancer may be mimicked perfectly histologically and still cancer not be present, is a mistaken and dangerous one. There is no doubt that many such cases are really cancerous.

6. Vital stains (Schiller, Ludford) offer a suitable method of diagnosing the earliest actual cancers, and of differentiating them from carcinoid conditions.

7. For the final histological diagnosis of suspicious tissue, in addition to vital staining there is required biopsy examination with the microscope. The biopsy should be cut transversely, be sectioned serially for microscopic study, and there must be repeated removal of tissue for examination if necessary.

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I. THE X-RAY MEASUREMENT OF THE FETAL HEAD DIAMETER *IN UTERO*[1]

An Accurate Technique by Means of Stereoroentgenometry

STEWART H. CLIFFORD, M.D., Boston

A NUMBER of methods of cephalometry *in utero* have been studied in this clinic during the past 2 years and the accuracy of each tested by comparison with the actual head measurements obtained after birth. The method finally evolved and here recommended is an adaptation of the stereoroentgenometric technique originally used by MacKenzie-Davidson and recently independently developed and described by Clayton R. Johnson. The advantage of the refinement of the technique herein described lies in that through tests applied to the finished film and through added controls it is possible to recognize, prior to the birth of the infant, those determinations which can be relied upon with a high degree of accuracy.

HISTORICAL

The earliest attempts to measure the fetal head *in utero* were by direct caliper measurements through the abdominal wall. This method was used with considerable success by Budin and Perret in 1899, Stone in 1905, McDonald in 1906, and Reed in 1917. McDonald was able to measure 41 heads with 100 per cent accuracy to within 0.5 centimeter and with 76 per cent accuracy to within 0.3 centimeter. Reed could obtain a measurement in only 85 out of 100 attempts to measure the head through the abdominal wall because of the presence of hard abdominal walls or excessive fluid or because of the small size of a premature infant's skull. He found his results were correct to within 0.5 centimeter in 93.5 per cent of the cases he could measure and to within 0.25 centimeter in 67.7 per cent. This method of cephalometry has not become popular in spite of its good showing probably because a high degree of personal skill must be acquired before the results obtained can equal those of the authors quoted and because it is in those cases in which the information is most desired that the measurements are apt to be unreliable, if not impossible to obtain.

Hirsch has given a concise review of the various attempts to utilize the X-ray for pelvimetry. He points out that 5 general methods were developed many years ago and all modern methods are, in fact, minor adaptations of these fundamental techniques:

1. *Comparative methods* in which the exposure of the pelvis in the living is compared with a normal specimen taken under identical conditions.

2. *Teleroentgenographic methods* in which the X-ray target is placed far enough from the object to obtain parallel rays and eliminate distortion.

3. *Frame methods*, first suggested by Fabre and Fouchet in 1899, in which a metal frame with its borders notched at centimeter intervals is placed around the patient's pelvis in the plane of the diameter to be measured. The popular Thoms technique is based upon this method except that after the first X-ray the patient is removed from the table and a lead plate perforated at centimeter intervals is placed in the plane to be measured and a second flash exposure made.

4. *Triangulation methods* in which two exposures are made on the same film or on two separate films that are later superimposed. In taking the X-rays the shift of the target is a known distance and the target-film distance is also known. "The two shadows of the point in the body are connected and the location of the point above the plate surface may be estimated by a mathematical formula or by a phantom with strings, utilizing the target plate distance, the target displacement and the shadow displacement distance as known factors." (5) This is the principle of the technique first used by Levy and Thumin and by MacKenzie-Davidson in 1898. The methods of Chamberlain and Newell (1921) and Johnson (1927) are recent examples.

[1] "Studies on the Reduction of the Newborn Infant Death Rate" from the Boston Lying-in Hospital, the Departments of Obstetrics and Pediatrics of the Harvard Medical School, and the Department of Child Hygiene of the Harvard School of Public Health. Part of a communication originally read before the Boston Obstetrical Society on October 18, 1932.

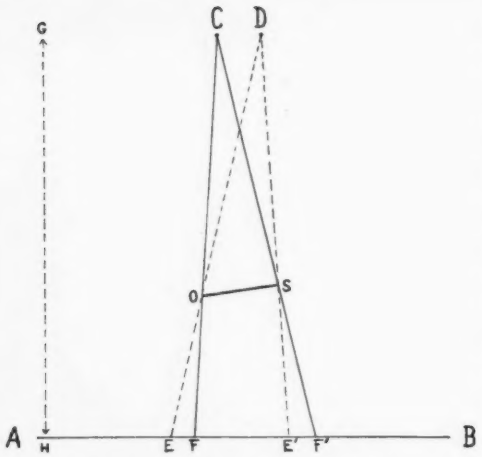

Fig. 1. Diagram illustrating the theory of stereoroentgenometry. For explanation see the text.

5. *Stereoscopic methods* "in which stereoscopic exposures are made and viewed in the regular way. By the use of an illuminated ruler or movable metallic points, placed directly in the phantom image, the pelvis may be accurately measured. . . . It is thus apparent that most of the methods reported in the last few years have been but modifications of the original principles laid down by Varnier, Albert, Fabre, and MacKenzie-Davidson." (5)

SEARCH FOR A SATISFACTORY METHOD OF CEPHALOMETRY

Direct measurements through the abdominal wall were not attempted for the reasons already enumerated. The method of teleroentgenometry was not applicable because of the long exposure required during which movement of the fetal head probably would occur. Thoms' modification of the frame method was used in 30 consecutive determinations with 57 per cent accuracy to within 0.3 centimeter and 67 per cent to within 0.5 centimeter. The mistaken predictions were found to be as much as 3.5 centimeters in error in some instances when compared with the actual head measurement. Walton's variation of Thoms' technique was given a brief trial but was found to possess no advantage over the former method. The frame method of cephalometry requires an experienced person to locate accurately the plane of the occiput and sinciput in space, in which plane the perforated lead plate must be placed for the subsequent flash exposure. This trained individual must obviously be present in person no matter at what hour the request for an X-ray is received. The chief objection to this method, however, was that in the individual case, prior to the birth of the baby, it was impossible to foretell whether the measurements obtained would represent one of the accurate readings or be one of the 33 per cent erroneous determinations. On the basis of our experience we could not recommend this method as sufficiently accurate and reliable for practical use.

In order to do the Thoms method justice the literature was reviewed to ascertain its success in other hands. Thoms, Walton, and Jarcho, although primarily interested in pelvimetry, have described this procedure as a means of fetal cephalometry. It was impossible to find in any of their published reports a single case in which the accuracy of a predicted fetal head size was verified by actual measurements obtained after birth.

The triangulation method as independently worked out by Johnson and called by him "stereoroentgenometry" was next tried; using Johnson's technique, we were able to predict the head size correctly in a fair percentage of the cases only then to encounter a series of erroneous determinations. It was impossible to ascertain from Johnson's writings what degree of success he had achieved for, although he described and recommended his technique as a means of cephalometry, no evidence was submitted in which the accuracy of his predictions was verified.

Hirsch has stated that while the stereoscopic method is used by Druner, Pulfrich, Trendelenburg, and others on the continent it is little used in this country. We have had no personal experience with this method.

Stereoroentgenometry. The theory of the method is better understood by reference to Figure 1, in which *AB* is the position of the X-ray film. *C* is the position of the target at one end of its shift from which the first exposure is made. *D* is the target position for

Fig. 2. Patient in position upon radioscopic table prior to obtaining stereoroentgenograms.

the second exposure 7 centimeters (2¾ inches) from *C*. *GH* is the distance from the plane of the target to the film or 63.5 centimeters (25 inches). *OS* is the position in space of the object to be measured. *E* is the projection of point *O* on to the film when exposed from target position *D*. *F* is the displaced position of *O's* shadow when the film is exposed from target position *C*. *E'* is the projection of point *S* on to the film when the target is at *D*. *F'* is the projection of point *S* when the target has been horizontally shifted to *C*.

Through the construction of a dummy with strings (Fig. 9), in which the original conditions under which the pictures were taken are duplicated, it is possible to start at the displaced shadows, *E* and *F*, of the common point *O* in space and retrace the path taken by the light rays back to their source at targets *C* and *D*. In such a reconstruction the point of crossing of the strings locates the position in space that must have been occupied by point *O* (Fig. 10). The position of point *S* in space can be similarly located and the distance between *O* and *S* directly measured (Fig. 11).

Roentgenological equipment necessary. Any standard radioscopic table (Fig. 2), equipped with a Potter-Bucky diaphragm and capable of taking stereoscopic pictures, a horizontal shift being used, can be readily adapted for the technique. The shift of the X-ray tube that we use is 7 centimeters (2¾ inches), 3.5 centimeters (1⅜ inches) to either side of the center.

The films when taken must be so marked that when the time comes for mensuration they can be placed in the stereoroentgenometer preserving the same relationship to the dummy targets that they did to the original ones. The longitudinal plane of the targets can be identified if 3 or 4 lead shot are embedded, about 6 inches apart, into the midline of the table surface so that their images will be cast upon the exposed film (Fig. 3). These markers must be planted at mid-points in the cross diameter of the table so that if a plumb line were to be dropped from the target center at either end of its longitudinal shift it would fall on a line connecting these markers.

The lateral plane of the target is located in the exposed film by the shadow of a wire that is stretched across the middle of the cassette

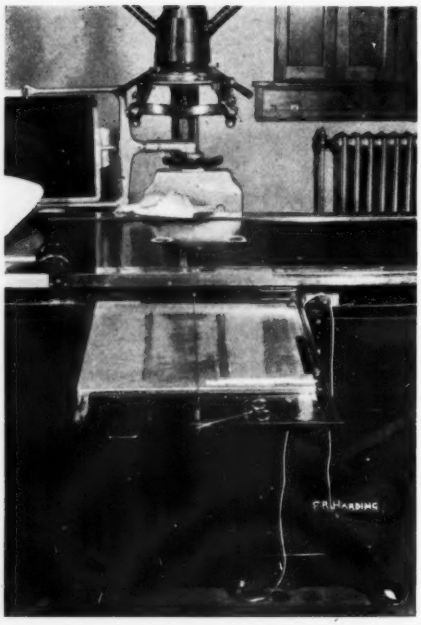

Fig. 3. Photograph illustrating the conversion of a standard radioscopic table into one capable of taking stereoroentgenograms. Lead shot have been buried in the surface of the table in the centers of the paper rings. A length of flexible wire has been fastened in the center of the inner side of the tray, drawn across the surface of the cassette and through a notch cut in the center of the outer edge of the tray where it is clamped in position.

(Fig. 3). The inner end of this wire is permanently fastened through a hole drilled in the middle of the inner edge of the Bucky diaphragm tray. It is then drawn tightly across the top of the cassette and through a notch that is cut in the center of the outer edge of the tray and here clamped in position. In the finished plate this wire crosses the line of the lead markers at right angles and their intersection identifies the point perpendicularly below the center of the X-ray target when it is at its normal resting position in the mid-point of the stereoshift.

The technique is checked for technical errors by securing two 10 centimeter metal rods at different points upon the patient's abdomen so that their shadows will appear in the finished plate (Fig. 2).

Mensuration equipment necessary. The finished X-ray films are measured through an instrument called by Johnson a "stereoroentgenometer." Figures 9, 10, 11 demonstrate that it is not as formidable as its name would imply. The apparatus pictured is a homely copy of that used by Johnson but has the advantage of being inexpensive and simple to make while at the same time it gives very accurate readings. The base of the frame serves to hold the X-ray plates in position on the viewing cabinet. The under surface of the projecting arm is 63.5 centimeters (25 inches) from the surface of the films. Three small holes are drilled through this arm: the middle one represents the target at its normal position in the center of the shift and through this hole a plumb-bob is suspended to locate the intersection of the cross wire and the lead marker lines. The two other holes are placed 3.5 centimeters (1⅜ inches) to either side of the middle hole in the line of the longitudinal tube shift. Through each of these a round elastic cord is passed and attached one to each arm of a compass. Adjustable metal pointers are provided to record the position in space of the objects located.

The X-rays are viewed through a horizontal illuminated cabinet. A centimeter rule and a Bertillon cephalometer capable of measuring 0.1 centimeter complete the list of equipment.

Roentgenographic technique. The patient is placed upon the table in a horizontal position (Fig. 2). The tube is centered over the approximate location of the fetal head. The Potter-Bucky diaphragm, with its tray containing the unexposed film, is released from its attachment to the X-ray tube carriage, leaving the tube free for its longitudinal shift of 3.5 centimeters to either side of this central point. The brakes of the Bucky diaphragm are locked, firmly anchoring it to the table, to guard against accidental dislocation of the X-ray plate during the examination. The flexible picture wire is drawn tightly across the top of the cassette, through the notch and clamped in position (Fig. 3). One of the 10 centimeter rods is fastened with adhesive tape over the patient's symphysis and the other is located at some convenient point on the abdomen. The patient's abdomen is firmly compressed by a binder attached to the table

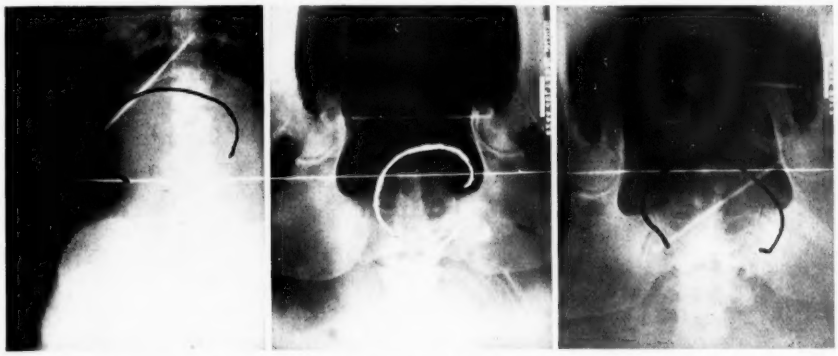

Fig. 4. Skiagrams with the fetal heads outlined, demonstrating satisfactory lateral views of the skull from which occipitofrontal diameters can be obtained.

The tube is placed at one end of the stereoshift and the first exposure is taken. We are using a Westinghouse radiographic, heavy duty tube with a 4½ to 5 inch spark-gap, 50 milliamperes, and an exposure of from 6 to 12 seconds.

A fresh cassette is placed in the tray, the wire redrawn across its surface, the Potter-Bucky diaphragm reset, the target displaced to its second position and the final exposure is made.

A review of important points in the technique influencing its accuracy. 1. The target, when at the center of its longitudinal shift, must be in a plumb line with the intersection of the line of the lead markers and the cross wire over the cassette.

2. The longitudinal shift of the X-ray target must be not more or less than 7 centimeters. The force of inertia may carry the X-ray tube beyond the shift stop unless the apparatus is rigidly locked.

3. The target film distance must always be 63.5 centimeters (25 inches).

4. The Potter-Bucky diaphragm carriage must be locked in its tracks so that the position of the X-ray plates will not alter their relationship to the rest of the apparatus. Unless this precaution is taken the carriage may be moved in the haste of introducing the second X-ray film and resetting the diaphragm. Such a shift upsets all calculations and results in a false reading.

5. The patient must not move between the two exposures.

6. The hazard beyond our control is movement of the fetal head between the two exposures. The vast majority of unsuccessful examinations are due to this cause. The shorter the interval permitted to elapse between the two exposures the less will be the chance of motion spoiling the determination. An important feature of the technique here recommended is that a means is provided whereby evidence of fetal head movement may be detected in the finished film and an erroneous reading thus avoided.

Interpretation of the roentgenograms. I. Is there a measurable diameter of the fetal head present? Fortunately for the success of this method actual experience has demonstrated that, in the great majority of X-rays, the shadow of the greatest or occipitofrontal diameter of the head is cast upon the film. Thoms has shown that in the lateral view of the head the fetal skull may be rotated 36 degrees in either direction before the shadow of the occipitofrontal diameter is shortened a millimeter. Very little experience is required before a satisfactory lateral view of the head can be recognized on the finished plate (Fig. 4). The points to look for are a long oval silhouette in which the occiput and sinciput, the anterior and posterior fontanelles and the maxilla and mandible may be identified.

The anteroposterior shadow of the skull, from which the biparietal diameter may be ascertained, is encountered in about 7 per cent of the cases. A true anteroposterior silhouette (Fig. 5A) can be identified from the

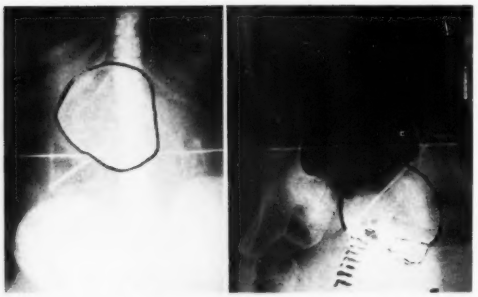

Fig. 5. A, Anteroposterior view of the fetal head from which a biparietal diameter can be obtained. B, Oblique view of the fetal skull from which no satisfactory measurement can be obtained.

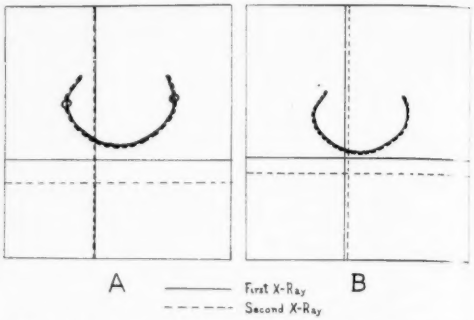

Fig. 6. A, Tracings from superimposed stereoroentgenograms in which no fetal head movement has occurred between the two exposures. With the head silhouettes perfectly superimposed the longitudinal lines of the lead markers also coincide. B, Tracing from a case where slight lateral movement of the fetal head occurred. With the head shadows superimposed the longitudinal lines are found to have separated but still remain parallel.

position of the anterior fontanelle, the mental point of the mandible and the pear shape of the shadow.

The oblique view of the head (Fig. 5B) is infrequently encountered but when it is, it must be recognized for from it no satisfactory measurement can be made. This shadow has a rounded contour, the fontanelles cannot be made out in the expected locations and the position of the mandible is abnormal. In cases of doubt the films may be viewed in the stereoscope where the true position of the head is readily seen.

II. Has there been movement of the fetal head between the two exposures? The important question as to whether there has been fetal movement can be answered by the following technique:

A. Identify the longitudinal plane of the target by passing a line through the shadows of the lead markers.

B. Outline the silhouette of the fetal head with a red lead pencil.

C. 1. Place both films on an illuminated viewing cabinet with the longitudinal lines superimposed. Slide the films along these lines until the skull silhouettes are superimposed (Fig. 6A). If there has been no motion the head shadows will exactly coincide while the longitudinal lines do likewise. When this condition is found to exist the films are ideal for measurement (Class A) and can be relied upon for almost 100 per cent accuracy.

2. When in order to superimpose the skull shadows, the longitudinal lines are found to have separated but have still remained parallel to each other, we have evidence that lateral motion of the head has occurred (Fig. 6B) without flexion, rotation, or extension. Our experience has shown that when the skull shadows can be made to coincide and when the longitudinal lines are not separated more than ¼ inch the movement of the head has not been sufficient materially to have altered the accuracy of a measurement. These films (Class B) have been accurate to within 0.5 centimeter in 100 per cent of the cases.

3. When in order to make the head shadows coincide the longitudinal lines must be made to cross each other we have evidence of flexion or extension of the head (Fig. 7X). When this flexion occurs the plates are valueless for accurate mensuration (Class O) and the examination must be repeated.

4. When it is impossible to make the two skull shadows superimpose perfectly (Fig. 7O), one usually being shorter and rounder than the other, we have evidence that there has been rotation of the head between these plates and these films must be discarded (Class O) and a repeat examination requested.

Preparing the films for mensuration. Perforate the ends of the metal rod shadows with a pin.

2. On one of the films mark by perforation the ends of the diameter of the skull to be

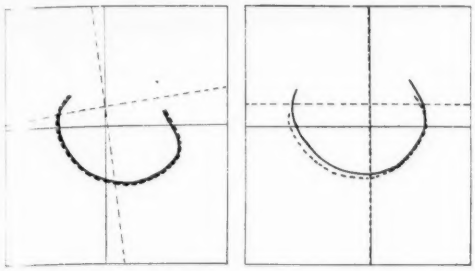

Fig. 7. X, Tracing from a case in which flexion or extension of the fetal head occurred between the two exposures. With the head silhouettes coinciding the longitudinal lines are found to have crossed each other. O, Tracing from a case in which rotation of the fetal skull occurred. The head shadows cannot be made to coincide, one being shorter and rounder while the other is more oval and longer.

measured. If the occipitofrontal diameter is to be obtained the greatest possible diameter of the skull is used.

3. Superimpose both head silhouettes with the longitudinal lines either coinciding or parallel. Locate identical points on the second skull by perforating through the holes already made.

Actual technique of mensuration. 1. Superimpose the longitudinal lines and the shadows of the lateral cross wires and place the films in this position upon the viewing cabinet (Fig. 8).

2. Place the stereoroentgenometer squarely upon the films and drop the plumb bob, adjusting the films so that it falls at the intersection of the cross lines (Fig. 9).

3. Cross the elastic strings once and place the compass ends on the displaced identical points of one end of the skull diameter to be first located. Fix one pointer at the point of intersection of the strings (Fig. 10). In a similar manner measure the displaced identical points of the other end of the skull diameter and adjust the second pointer to the point of intersection of the strings.

4. Actually measure the distance between the two pointers (Fig. 11).

5. Following the same routine check the accuracy of the technique by measuring the displaced shadows of the 10 centimeter rods. The error should not exceed 0.2 centimeter.

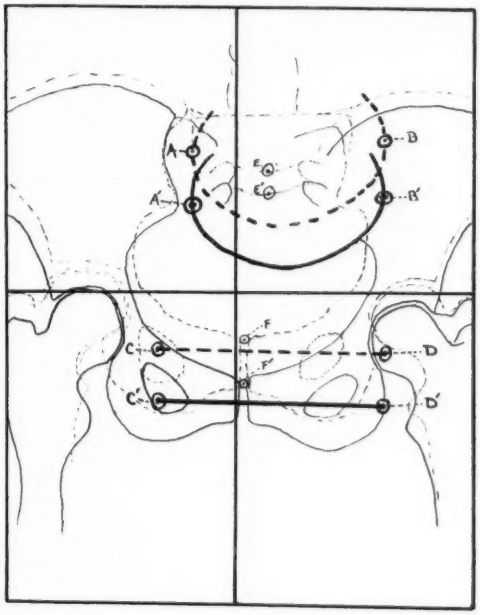

Fig. 8. Tracing from superimposed stereoroentgenograms in position for mensuration with the longitudinal and lateral lines coinciding.

STATEMENT OF RESULTS

1. The technique described subdivides the X-ray films into 3 classes depending on whether or not movement of the fetal head has taken place between the 2 exposures: Class A films in which there has been no motion; Class B films in which there has been slight motion in the lateral plane; Class O films in which there has been so much motion that any attempt at mensuration will give unreliable results.

2. By means of the stereoroentgenometric technique, 167 consecutive X-ray determinations of the size of the fetal head *in utero* were made and checked by actual measurement of the head at birth.

Ninety-one of the plates were rated Class A and were 97 per cent correct to within 0.3 centimeter while 99 per cent were correct to within 0.5 centimeter.

Of the plates 26 were rated Class B and were 80 per cent correct to within 0.3 centimeter and 100 per cent correct to within 0.5 centimeter.

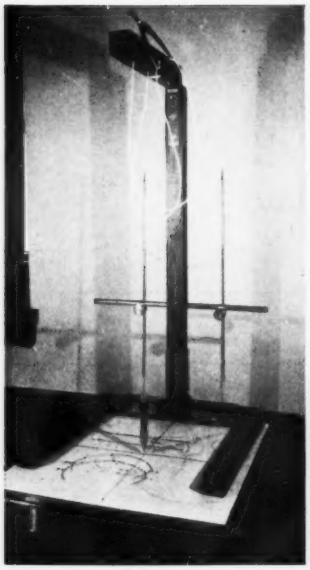

Fig. 9.

Fig. 9. Stereoroentgenometer located for mensuration by means of a plumb-bob dropped to the intersection of the cross lines.

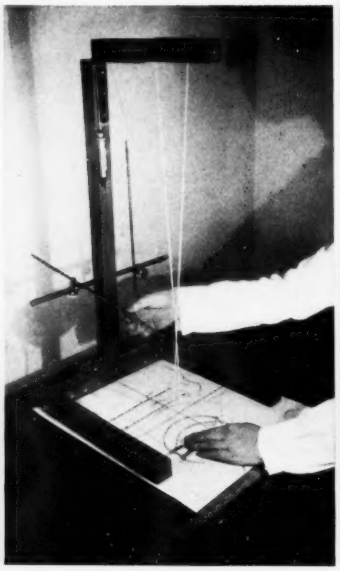

Fig. 10.

Fig. 10. Locating in space the end point of one of the diameters of the fetal head to be measured.

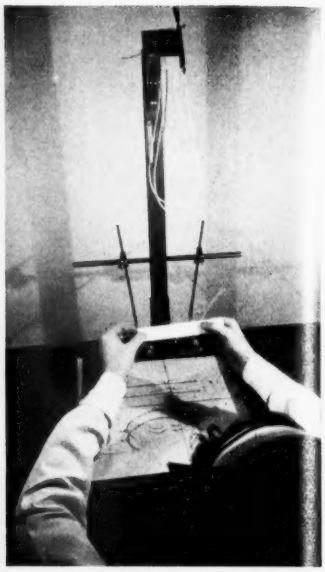

Fig. 11.

Fig. 11. Actual measurement between the two discovered end points of the fetal head diameter.

Fifty determinations were in the inaccurate and unmeasurable Class O.

3. In 70 per cent of the total of 167 stereoroentgenograms, a satisfactory X-ray, of Classes A or B, was obtained and an accurate prediction given at the first X-ray examination.

In 78 per cent of the 124 vertex presentations found in this group it was possible to obtain a satisfactory X-ray and give an accurate prediction at the first examination.

In 49 per cent of the 43 breech presentations found in this series it was possible to obtain a satisfactory X-ray and give an accurate prediction at the first examination.

4. In 147 X-ray examinations, 117 in this series and 30 using the lead grid, a satisfactory occipitofrontal diameter was found presenting in 93 per cent of the cases. A measurable biparietal diameter usually was obtained in the remainder. The oblique diameter was infrequently encountered.

5. The principal cause of the 50 unsuccessful X-ray examinations was movement of the fetal head between the 2 exposures.

EVALUATION

Stereoroentgenometry would qualify as a most satisfactory method of cephalometry if movement of the fetal head *in utero* could be eliminated. This factor cannot be controlled, but the method describes a means of recognizing this movement when it has occurred and thus avoids an unreliable prediction.

Very little movement of the fetal head is encountered in vertex presentations because of the wedging of the head in the neck of the uterus. The results of stereoroentgenometry are entirely satisfactory in this group with 80 per cent of all attempted examinations resulting in accurate predictions. When movement does occur and thus produces an unmeasurable film, the chances are that a second examination will result in an accurate measurement.

It has been in the breech presentations that the results have been the least satisfactory for here, with the head free to move in the fundus of the uterus, considerable movement is encountered. An attempt to obtain a measur-

able film of the head in this group carries with it a 50 per cent chance for success at the first examination. The law of probability greatly increases the chances for success with each succeeding examination.

Fully appreciating the shortcomings of this method of cephalometry, the fact remains that a measurable X-ray in which there has been little or no movement of the fetal head can be obtained in a high percentage of the cases examined, and when such a film has been identified an accurate prediction as to the actual size of the skull can be given in practically every case.

The question may well be asked as to why X-ray pelvimetry has not been mentioned in connection with the studies on X-ray cephalometry. As a matter of fact, we have attempted to measure the true conjugate diameter of the pelvis in all of the cases examined, but as yet we are not convinced of the accuracy of any of the methods advocated. It was an easy matter to check the accuracy of any method of cephalometry by actual measurements of the head after birth. It was extremely difficult to know whether the figure obtained for the true conjugate by X-ray actually represented the true diameter. The verification of the X-ray prediction in this case can be accomplished only through actually measuring the true conjugate during an abdominal exploration or at postmorten examination. The estimated conjugate vera that we obtained by X-ray examination and from the clinical determination of the diagonal and external conjugate did not conform with any degree of accuracy. Thoms, Chamberlain and Newell, Roberts, Walton, Jarcho, Heublein et al., and Moore have all written on X-ray pelvimetry but none have submitted data to confirm the accuracy of their determinations. Johnson offered the external conjugate diameter to compare with his estimated true conjugate, but the average discrepancy between the estimated true conjugate from the 2 sources was 2.5 centimeters.

It seems reasonable that before any method of pelvimetry can be accepted as an adjunct to obstetrical practice, on the results of which the patient's welfare may depend, it must first be required to pass a rigid test for accuracy. *A priori*, a method such as Johnson's that has proved its ability to measure the fetal head, should be capable of measuring the pelvic diameters. There is certainly no problem of motion in pelvimetry such as there is in fetometry, but to replace it there is the real difficulty as to where, on the flat plate, the end points of the true conjugate shall be placed. At present we are comparing a series of actual true conjugate determinations, obtained incidentally during abdominal operations, with the estimated true conjugate obtained later by the stereoroentgenometric technique. Until the reliability of any method of pelvimetry is thus established it cannot be accepted as of practical value.

CONCLUSIONS

A technique of stereoroentgenometry has been described by which it is possible to predict the size of the fetal head *in utero* to within 0.3 centimeter in 97 per cent of the cases in which an occipitofrontal or biparietal diameter is present and movement of the head between the stereoroentgenograms has not occurred.

Means are described whereby the X-ray picture of a measurable head diameter can be identified and motion of the fetal head between the 2 exposures can be detected when it occurs.

Eighty per cent of the vertex presentations and 50 per cent of the breech presentations were accurately measured at the first examination. Movement of the fetal head between the 2 necessary X-ray exposures was found to account for practically all of the unsatisfactory examinations.

I wish to express my appreciation for the interest and co-operation of Dr. Frederic C. Irving, Dr. Samuel A. Robins, and the members of the house staff of the Boston Lying-in Hospital. I am especially indebted to Dr. Thomas R. Goethals for his valuable assistance throughout the course of this study and to Miss Helen Wilkins, R.N., for her skillful roentgenography.

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CLINICAL SURGERY

A SAFE AND SATISFACTORY METHOD OF ANÆSTHESIA FOR TOXIC GOITER PATIENTS

WILLARD BARTLETT, M.D., F.A.C.S., AND WILLARD BARTLETT, JR., M.D., ST. LOUIS, MISSOURI

CONSIDERATIONS of a physiological nature should obtain in influencing us to choose an anæsthesia method which comports with the peculiar needs of the hyperthyroid patient. The observer who has seen a restless patient of this class become perfectly quiet immediately after being placed in the oxygen tent requires no further argument to convince him that "local" possesses an undoubted advantage over any oxygen displacing inhalation anæsthesia. This is the definite reason why local anæsthesia should be employed on the toxic thyroid patient, it being illogical to interfere with the oxygen supply (it will be generally admitted that every form of inhalation anæsthesia disturbs the cellular respiration—Crile—and is hence to some extent dangerous) by inhalation anæsthesia of a patient whose oxygen need is increased in proportion to the severity of her malady, especially if an adequate technique will prevent the patient from recognizing or remembering the operative procedure. This is obviously essential if the highly nervous individual is to be afforded the advantages of local anæsthesia.

It happens too, now and then, that a thyrotoxic storm follows operation where least expected. Certain patients are always *potentially* toxic if not actually so when examined. These are no doubt in great part individuals whom we see in a more or less complete remission though we are, or seem to be, unable to establish the fact that they have ever been hyperthyroid. A further reason for employing some form of local is that the type of anæsthetic regulates in many instances the amount of bleeding caused by a thyroidectomy, hence regulates automatically the period required for hæmostasis, therefore determines to no small extent the length of the operation. Inhalation anæsthesia tends to increase the blood pressure, something especially noticeable in a patient who struggles at all; particularly is it true when cyanosis makes its appearance as gas supplants oxygen, or when mucous floods the air passages, or when the trachea is maltreated as happens more often to the fully unconscious patient whose pressure symptoms disturb the operator as well as herself.

A minor advantage for the use of "local" lies in the fact that no atropine is needed to prevent or limit the excessive secretion of the mucus which complicates the employment of inhalation anæsthesia. This outpouring has gone so far as to cause interruption of the operation in our hands; it also has persisted as the most disagreeable feature of the few early postoperative days. Atropine tends further to rouse the sleepy patient if employed along with basal anæsthesia, hence its use is not to be recommended if it can be avoided (Gruber); still we are forced to employ it, though very rarely, when an excessive amount of mucus is secreted no matter what the circumstances.

We never operate on a toxic goiter patient until a relatively satisfactory state of remission has been reached; consequently, a certain degree of inhalation anæsthesia may be tolerated so far as the patient's sensitivity to oxygen deficiency is concerned although one who goes through operation under local anæsthesia alone is certainly somewhat better off and the surgeon is definitely in a better position if there be no respiratory overactivity and no increased consequential bleeding. On the other hand, one must admit that no such patient is wholly comfortable on the table; confinement of legs and arms as well as the position of the head leave much to be desired; there is often a sense of suffocation from pressure on the trachea; there is surely some retraction of muscles and traction on thyroid tissue which contribute to the discomfort; there is, too, a general sense of danger while in the operating room. Many sensitive patients, even though drugged, are unsuited to this combination of circumstances hence a little gas (we prefer ethylene) should always be given or even urged on the patient when any need of any sort arises. A perfect thyroidectomy is the object aimed at; the anæsthesia must always be regarded as of secondary importance.

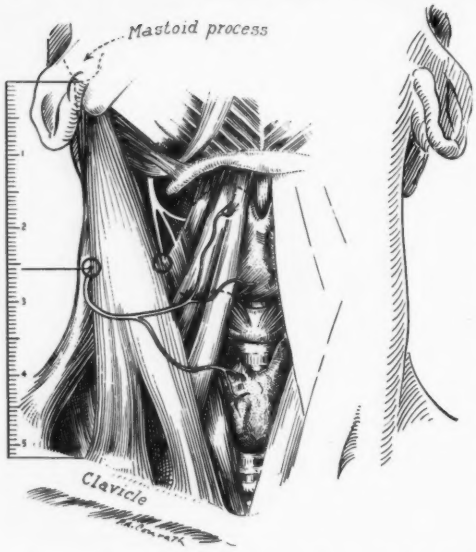


Fig. 1. The heavy circle marks indicate the injection points for blocking the nerve supply to every structure in front of the thyroid gland. As a matter of course two injections are required on each side of the neck.

"Local" is a *failure if the patient realizes the nature* of her anæsthesia (when toxic). It must be "covered" by "dope" before entering operating room or by gas in the operating room. We prefer the former because blood pressure is usually lowered; the operating room is practically never recognized; there is no cyanosis, increased bleeding, difficulty with vomiting, or difficulty in managing the patient. Neck muscles are relaxed, hence access to the tumor is simplified while it gives postoperative sedation as well. The preoperative drugging of patients on whom local anæsthesia is to be employed is a matter worthy of more detailed study. Certain types, for example, of toxic goiter patients are totally unsuited to the use of local anæsthesia without preliminary drugging or gas inhalation on the table. One may go to the other extreme and so heavily drug an individual that an operation may be done without any type of local or other anæsthesia. In this event, of course, injections are not felt but the margin of safety is rendered so narrow that this extreme is always as objectionable as the one first mentioned. There is, however, a middle ground where a certain moderate degree of drugging renders the patient oblivious to her surroundings but still leaves her the power of cooperation even though she is conscious of what is going on. This co-operation is indispensable else she is unmanageable on one hand or too close to the dead line on the other. Phenobarbital sodium, grains 15, in broken doses,[1] has served us better than any other drug we have used for this purpose, though on occasion we have had to supplement it with a small dose of morphine before the ideal condition has been realized.

Toxic goiter patients were once operated upon, or at least anæsthetized, in bed in our service, but the procedure of managing them has been much simplified by the semi-anæsthesia thus induced. They are now taken to the operating room with no special precautions while under its influence; such a patient has no anticipation, no experience, and no recollection of the operating room, hence we no longer find any advantage in doing thyroid operations in the patient's bed with the undesirable features attendant on same. An especial consideration is to be accorded the patient who must be deceived as to the second stage of a hemithyroidectomy; she is told that a laboratory examination is indicated, is given the basal anæsthesia in mildly augmented dose, then when she wakes she is back in bed, having been to the operating room without her knowledge.

No general rule for anæsthesia is applicable to 100 per cent of the patients as will be shown by a perusal of two case history abstracts which follow. The patient's nervous make-up due to inheritance, environment, or disease is primarily responsible for the degree of anæsthesia we are able to secure by whatever method. Mrs. B., July 16, 1931, had been given phanodorn, grains 15, morphine, grain ¼, superficial nerve block, a little gas, still any manipulation of her neck caused struggling. We cut "flaps" and put back to bed this toxic goiter patient who was more unstable than we had supposed. (Needle pricks during skin closure awakened no response, proving that she had a fair analgesia.) This should not happen today in view of our improved ability to judge the patient's pre-operative condition. A different situation was manifest with Mrs. M., September, 1931, who without any pre-operative anæsthetic drug was calm and co-operative for ligation, everything being understood though every barbiturate had made her maniacal, so uncontrollable in fact that return to bed was necessitated on a previous occasion. Morphine had caused excessive nausea and vomiting at a second trial. Full ethylene was satisfactory after she refused "local" on a third attempt. All "general" rules were abandoned finally, but the patient was satisfactorily treated by individualization. (We

[1] Surg., Gynec. & Obst., 1930, li, 217-224.

were still doing a few ligations 2 years ago while still developing the anæsthesia method which is now our standard.)

Individualization is the key to success in the use of local anæsthesia. In many instances the mask is never on the face after the skin incision; some patients seem to get much soothing effect from its mere presence while a very few really require an infinitesimal amount of gas at some period of the operation, luxation of a lobe for example. The surgeon should keep in mind the fact that the degree of anæsthesia is dependent first of all upon the personality of the patient; one who is by nature unruly and by circumstance undisciplined *cannot be completely controlled by any drug having a general action short of the danger line.* On the other hand, the margin of safety is increased according to the co-operative spirit manifested by the individual. Dr. Sidney I. Schwab long ago called my attention to this fact which has been most helpful in my operative work and should be in the background of every anæsthesia no matter what its nature—this general principle should, incidentally, be well known to every patient about to enter the anæsthetic state.

A trained and sympathetic anæsthetist is indispensable for "local" work upon the toxic goiter patient. The mask is off her face most of the time, as remarked, though she is stabilized at all times by the right sort of a voice at her ear. Any minor complaint whatsoever must be met in this manner, while dilute carbon dioxide and oxygen seem to combat any tendency to nausea or vomiting.

Some compromise between "general" and "local" seems to produce the most nearly ideal anæsthesia for the *average* thyroid patient; true for the surgeon, at least, who considers the thyroidectomy of primary importance even though he may lean strongly toward the anæsthesia fad of the moment. The method which we find most satisfactory today is carried out as a routine in the following manner.

First step. The patient under the partial influence of a basal anæsthesia is placed upon the table and the four sites of injection marked with pen and ink. (Numerous dissections made by Dr. George A. Seib, instructor in anatomy, Washington University School of Medicine, demonstrated the advisability of locating the sites of injection at the points chosen.) These tiny cross marks are not obliterated by the subsequent measures to insure skin asepsis unless some water soluble antiseptic be used, something which we do not find necessary. Points for injection are determined as follows: posterior border of sternomastoid muscle is very carefully marked along the edge of a small ruler, the ends of which are placed on the appropriate anatomical landmarks on the skull and clavicle; exactly half the distance between these two points is then determined and a cross mark made; the anterior border of the sternomastoid is then determined in much the same manner and carefully marked along a "straight edge"; a cross mark is made at a point slightly lower than that on the posterior border of the muscle about on a level with the laryngeal tubercule and just above the lower border of the thyroid cartilage which can be plainly felt.

Second step. The skin of the neck is cleaned up with benzine and sterilized by spraying upon it merthiolate, a superficial soap and water cleansing having been made before the patient is brought to the operating room.

Third step. The patient is draped as for operation leaving the four tiny injection cross marks exposed.

Fourth step. A light gas anæsthesia is started and carried to the depth at which needle pricks will not be noted. Then through the posterior of these two injection points we block that portion of the superficial cervical plexus which curves around the posterior margin of the sternomastoid at its middle, using about 3 cubic centimeters of 2 per cent procaine without adrenalin, thus securing approximately a one hour anæsthesia of the skin and fat. It is simple enough to get an adequate conduction anæsthesia of the skin covering the thyroid region in the way we have outlined, but it is absolutely necessary in addition that we anæsthetize the three ribbon muscles as well as the fasciæ covering them and connecting the two across the midline. This can be accomplished through the anterior injection point by blocking the branches of the descendens hypoglossi where the three separate, to enter the muscles just mentioned, in a triangular space bounded by the upper border of the thyroid cartilage above, the sternothyroid muscle and the sternomastoid muscle on two sides. A needle can be inserted into this space through the above mentioned opening directly in front of the sternomastoid at a little lower level than that on posterior border, a like amount of the same drug being used.

Fifth step. The incision is made, then the mask removed, and usually no more gas employed unless for some reason the patient demands it.

Sixth step. We also *infiltrate each upper pole* after its exposure with 2 per cent procaine just before dividing it and sometimes do the same in

the region where the thyroid is attached to the trachea. Thus is a painless bilateral resection operation insured after needle thrusts, four of them made prior to skin incision, the fifth and sixth, after the upper thyroid poles are exposed.

There are individual instances in which it is thought best to use no gas at all—it may be for no more cogent reason than to satisfy the whim of a somewhat unusual patient. In such instances we go to the patient's bedside half an hour before the time set for operation, spray the puncture sites with ethyl chloride, then inject all four areas with nupercaine, 1:1000 solution, then permit her to fall asleep once more, being thus assured of a six hour local anæsthesia. This procedure shortens her stay in the operating room; it also decreases the number of technical procedures to which she must submit while there—incidentally, about one-half hour must elapse before the full effect of nupercaine is secured.

It is particularly important for the patient under local anæsthesia alone that her surgeon be in possession of the knowledge that pain sense disappears before that of pressure as has been demonstrated by Heinbecker, of the Washington University School of Medicine. Herein lies the distinct advantage in many instances of picking up the skin while incising it, thus protecting the deeper tissues against the sensation of pressure which would otherwise be produced. One great advantage in using some type of conduction anæsthesia in which no procaine or other solution is seen in the operation field lies in the assurance that there will be no chronic œdema or interference with wound healing which have often in the past been urged as objections to a local anæsthesia method which depended upon infiltration. Nerve block has an especial indication when one must remove a second lobe during the healing period of a wound made for the primary lobectomy, there being several generally accepted reasons why one does not attempt the "infiltration" of an œdematous, or an infiltrated, or a potentially infected area.

THE SURGICAL TREATMENT OF STERILITY CAUSED BY OCCLUSION OF THE FALLOPIAN TUBES

CHARLES C. NORRIS, M.D., F.A.C.S., PHILADELPHIA
From the Department of Obstetrics and Gynecology and the Gynecean Hospital Institute of Gynecologic Research, University of Pennsylvania

IN the treatment of sterility it is essential to ascertain the cause of the condition. More than one cause may be present. One of the most frequent conditions producing sterility in women is occlusion of the fallopian tubes. About one-third of all cases of sterility in women is due to the effects of salpingitis. Inflammatory alterations of the tubes are usually easily recognized by bimanual examination and a more or less characteristic history is generally present. Old, small, quiescent, flaccid lesions, especially when occurring in women possessing thick or extremely muscular abdominal walls, are more difficult to detect by clinical methods, and cases in which recognition of the occlusion is impossible without the aid of insufflation or salpingography are by no means infrequent. It is particularly in the latter type, i.e., the lesions are not especially massive and all active infection has long since subsided, that surgical intervention to overcome the occlusion of the tubes is most likely to be successful. Even under the most favorable circumstances, permanent restoration of the patency of the occluded tubes by surgical measures is successful in only a limited number of cases. Although the operative risk is slight, the operation is nevertheless a major one and is associated with a small but definite mortality and morbidity. In a certain proportion of cases adhesions reform and occlusion again develops. This may occur during convalescence or less frequently at a later date. Furthermore, patency may be permanent, but pregnancy may not take place. Finally, the operation is usually not required except for the purpose of making fertility possible.

Only when the following conditions are present should operation be considered: The husband must be fertile, the woman must be in the childbearing age. It must be proved beyond doubt that both tubes are occluded. The infection which caused the tubal occlusion must have disappeared. This applies to infections within the tube and also in the lower genital tract. Apart from other well founded objections to operation during the period when viable organisms are present within the tube, surgical intervention is at this time certain to be followed by adhesions which usually defeat the ends of the operation and result in re-occlusion of the lumen of the tube. If, as in the case of gonorrhœa, infection is present in the lower genital tract but has subsided in areas above the internal os, upward extension may occur again at any time and thereby nullify the effects of operation. At least one ovary must be functioning. Even after the most careful preoperative study the surgeon cannot promise too much, not only for the reasons already mentioned, but also because conditions may be found after opening the abdomen which make a satisfactory operation almost impossible. On the other hand, pregnancy does occasionally follow when least expected. Patients who desire fertility are generally of the intelligent class. It is best therefore to explain the situation and permit them to make the request for operation if they so desire. In performing the operation the utmost gentleness in handling tissue and careful peritonealization is important. Only thin, round pointed needles and fine catgut should be employed. Hæmostasis is important, but as few stitches as possible should be used and when feasible these should be buried. Catgut and small blood clots are fertile sources for the development of postoperative adhesions. It is generally preferable to cut rather than break adhesions. In some instances it is better not to disturb ovarian adhesion if by so doing the blood supply of the ovary is likely to be impaired. It is decidedly preferable to conserve both ovaries and tubes although migration of the ovum from one ovary to the opposite tube may occur. When the uterus is in retroposition, this should be corrected at the same sitting. A modified Coffey operation is often satisfactory for this purpose. At all events, a form of suspension should be selected which will not result in malposition or dystocia if pregnancy follows. A wide dilatation of the cervix is routinely employed and any cervical lesions should receive appropriate treatment. Erosions are generally best treated with the cautery.

If there has been no amenorrhœa, the patency of the tubes is tested by the Rubin method 3 months after operation and again 6 months later. This is advisable not only to determine the effects of the operation but also because even with moderate pressures this procedure may occasionally overcome light postoperative adhesions and thereby maintain patency. If there is any suspicion of pregnancy being present the patency test is

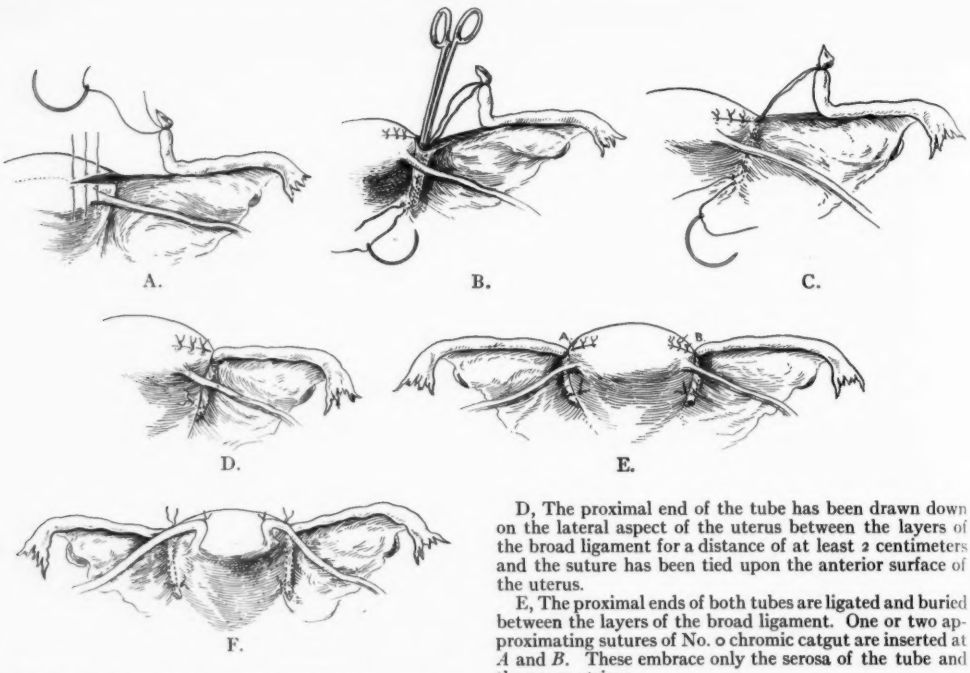


Fig. 1. Sterilization. A, Excision of the intramural portion of the tube. The proximal end of the tube has been tightly ligated with a fine silk and the ends of the ligature left long. No. 0 chromic catgut sutures have been placed in the uterine wound. (The illustration shows the tube separated from the mesosalpinx for a greater distance than is necessary or advisable.)

B, The sutures in the uterine wound have been tied. The anterior and posterior layers of the broad ligament are being separated with a hæmostat close to the uterine wall for a depth of 2 centimeters. The ends of the tubal ligatures have been carried to the bottom of the pocket thus formed and brought out through the uterine wall on the anterior surface, care being taken to carry them well down but not to wound the bladder. The blood vessels may be avoided by placing these sutures somewhat anteriorly.

C, The hæmostat has been withdrawn and upon traction of the sutures the ligated end of the tube will be drawn between the layers of the broad ligament.

D, The proximal end of the tube has been drawn down on the lateral aspect of the uterus between the layers of the broad ligament for a distance of at least 2 centimeters and the suture has been tied upon the anterior surface of the uterus.

E, The proximal ends of both tubes are ligated and buried between the layers of the broad ligament. One or two approximating sutures of No. 0 chromic catgut are inserted at *A* and *B*. These embrace only the serosa of the tube and the myometrium.

F, If the uterus is in retrodisplacement and the round ligaments relaxed a modified Coffey operation may be performed as a final step in the sterilization operation. The round ligaments are thus shortened, good peritonealization secured, and the uterus brought into normal position. A continuous Cushing's suture of No. 0 chromic catgut is used for the plication of the round ligaments.

omitted or delayed and either an Aschheim-Zondek or Friedman test may be employed. In the event of pregnancy following the operation, delivery for many reasons is best conducted in a hospital. The probability of rupture of one of the uterine cicatrices is extremely remote, however this is a possibility which should be borne in mind.

I have performed the operation eight times. In this series there was no mortality. Pregnancy followed four times. There were no abortions. Three patients were delivered by spontaneous labor at term and 1 by an elective cæsarean section 2 weeks before the date of expected confinement. In a fifth case one tube was patent 6 months after operation, but pregnancy has not occurred. In 2 cases occlusion of both tubes recurred within 3 months of operation and in 1 case it was not possible to test the patency of the tubes, but as pregnancy has not occurred this case is probably a failure.

No effort has been made to review the literature on this subject, but it is probable that the proportion of successes herein recorded could not be maintained in a large series. The following are the abbreviated histories of the 4 cases in which pregnancy followed the operation. It will be noted that in one of these there was no disease of the tubes, operation for sterilization having been performed in conjunction with a cæsarean section.

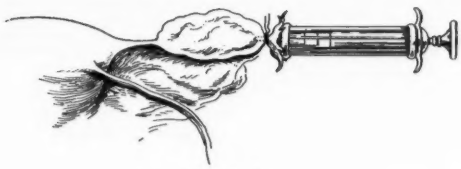


Fig. 2, A.

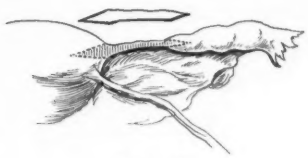


Fig. 2, B.

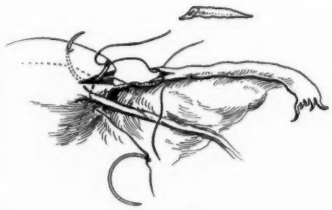


Fig. 2, C.

Fig. 2, D.

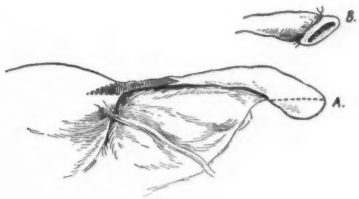


Fig. 3

Fig. 2. A, An elongated tube the seat of an old salpingitis. The infection has disappeared but a few adhesions remain. The lumen in the inner one-third of the tube is obliterated. A syringe point is inserted through the external abdominal ostium and a heavy catgut ligature lightly tied around the nozzle to prevent the escape of air. Compression of the syringe (plunger) shows the patent portion of the lumen dilated with air and indicates the extent of the inner portion of the tube which must be excised.

B, The shaded portion of the tube indicates the part which is to be excised and the lines of incision.

C, Excision of entire intramural and part of, or the isthmus of, the tube. It is important that the opening into the uterine cavity be sufficiently large to admit the tube without undue constriction. From the proximal end of the portion of the tube which is to be engrafted a wedge-shaped portion is excised and the tube further split for a distance of about seven millimeters. The split should be directly through the lumen. A No. 0 chromic catgut suture is passed through the upper edge of the wedge and another through the lower; these are passed into the uterine cavity and the tube drawn into place. Care should be taken so to place these sutures that when tied the split ends of the tube are widely separated insuring patency of the lumen.

D, The obliterated portion of the tube has been excised. The remaining proximal end has been drawn into the uterine cavity and fixed in such a manner that the gaping ends of the wedge-shaped excision are separated. One or two approximating fine catgut sutures at points *A* and *B* are generally necessary. These embrace the myometrium and the serosa of the tube.

Fig. 3. Hydrosalpinx. A, The distal end of the tube is obliquely amputated. The syringe test (Curtis test) (Fig. 2, A) is then employed and indicates how much of the isthmus of the tube is to be excised. The dotted lines indicate the lines of excision. B, Shows the distal end of the tube has been amputated obliquely and the mucosa and probably a part of the muscularis have been turned back and stitched to the serosa. The proximal end is then implanted into the uterine wound as shown in Figure 2, D.

CASE 1. Occlusion of the inner portion of both tubes. No apparent cause for the occlusion.

Age 32 years; married for 6 years; never employed contraceptive measures. No history of infection except that artificial insemination had been practiced repeatedly for a period of 2 years and that previous to this two dilatation operations had been performed in the hope of overcoming the sterility. Both husband and wife were healthy and athletic.

Pelvic examination showed the uterus in retroposition and the adnexa apparently normal. A suspension operation was suggested. At operation no adhesions were found, but the inner portions of both tubes were thin and cordlike. The outer two-thirds of the tubes appeared normal as were the ovaries. The Curtis test showed both tubes occluded in their inner portions. The occluded portions of the tubes were excised. Implantation was performed and the uterus suspended by the Coffey method. The cervix was widely dilated. Convalescence was normal. Neither the insufflation nor lipiodol test was employed after operation. Pregnancy occurred 2½ years later and was followed by a normal labor. The infant was normal.

CASE 2. Occlusion of the inner portion of both tubes probably postpartum in origin.

A white Jewess, aged 34 years, married for 10 years. Patient had one living child 9 years of age. She had had no abortions, and never used contraceptives. A history suggestive of a mild postpartum infection was present. There were no symptoms referable to the pelvis since convalescence from childbirth except the sterility.

Pelvic examination showed an apparently normal multiparous genital tract. Insufflation showed occlusion of both tubes. Salpingography showed that the fluid did not leave the uterine cavity. At operation there were practically no adhesions, the body of the uterus was normal, the tubes were unusually long, about 15 centimeters in length, the inner third of each tube was rather attenuated and the outer two-thirds appeared normal. The syringe test showed that the occlusion was present in only the proximal one-third of each tube. The ovaries were macroscopically normal. Bilateral implantation and routine dilatation of the cervix were performed and a small erosion of the cervix was cauterized. Convalescence was normal.

Examination 6 weeks after operation showed an apparently satisfactory result. A Rubin's test was to have been done 3 months after operation, but at this time it was found that the patient's period was 1 week overdue and subsequent development showed pregnancy. This patient was

delivered at term of an 8 pound normal male infant in good condition. Puerperium normal.

CASE 3. Small bilateral flaccid hydrosalpinges, probably of gonococcal origin.

Patient aged 26 years, married for 6 years; never pregnant. She had employed various contraceptives for the first year of married life, none since then. History of leucorrhœa beginning shortly after marriage which spontaneously disappeared 4 or 5 years ago. The patient had an attack of what was probably mild pelvic peritonitis about 6 months after marriage, but had no pelvic symptoms since. Husband and wife were in good health. Pelvic examination showed an essentially normal genital tract. There was no evidence of infection, the uterus was forward, movable, and normal in size. The adnexa were not palpable and there was no tenderness or induration in either ovarian region. The insufflation test showed occlusion of both tubes. Salpingography showed that no fluid left the uterus. At operation small flaccid bilateral hydrosalpinges were found and a few light adhesions between the tubes and ovaries on both sides. Adhesions were severed, new abdominal ostia were formed, and bilateral excision of the occluded inner portions of the tubes followed by implantation was performed. The appendix showed a few adhesions and was removed. The cervix was dilated. Convalescence was normal. Insufflation tests 3 and 6 months after operation showed both tubes patent. Pregnancy occurred 9 months after operation which resulted in a normal labor at term. A female infant in good condition was secured.

CASE 4. Sterilization at time of cæsarean section and 3 years later re-imbedding of the tubes into the uterine cornua.

Patient aged 34 years, married for 8 years. She had one living child delivered by a cæsarean section in another city. She had a moderately contracted pelvis. Two years later a second cæsarean section was performed by me which also resulted in a living child. At the request of both parents a sterilization operation was performed at this time by the method herein illustrated. Cæsarean section was selected as the method of delivery because of the previous section and the contracted pelvis. For 2 years the patient was sterile and at the completion of this period the couple changed their minds and wished another child. At this time the insufflation test showed no escape of air from the uterus.

At the time of operation only a few light adhesions were found. The ends of the tubes which had been inbedded between the layers of the broad ligaments were found so densely incorporated in the surrounding structures that no effort was made to remove them. The tubes were therefore amputated close to the uterus, tested for patency, and imbedded into the uterus. Convalescence was normal and 3 months later insufflation showed both to be patent. Pregnancy occurred 6 months later and a third cæsarean section was performed 2 weeks before the estimated date for confinement. A normal apparently full term living infant was secured. A second sterilization was not performed. Convalescence was normal.

SOME POINTS IN THE TREATMENT OF GENITO–URINARY TUBERCULOSIS[1]

T. E. HAMMOND, F.R.C.S., CARDIFF, WALES
Consulting Urologist, Welsh National Memorial Association; Assistant Surgeon, The Royal Infirmary, Cardiff

IN men there is an intimate relationship between the urinary and genital organs, and it is common for tuberculosis to involve both at the same time; in women combined lesions are very rare. It is important to differentiate between tuberculous disease which starts in the urinary tract and extends to the genital organs in 70 per cent of cases, and that which starts in the genital organs and later may involve the urinary tract. This is, however, rare and is seen usually as a terminal event. The former will be referred to as urinary tuberculosis and the latter as genital tuberculosis. These are different diseases and run a different course and require different treatment.

URINARY TUBERCULOSIS

I have never come across a case of primary tuberculosis of the bladder. The disease begins in the kidneys and in 92 per cent is at the start confined to one. It usually leads to complete destruction of the kidney and involves the bladder and genital system, and eventually the other kidney. So long as the disease is limited to the kidney, there may be few symptoms and none may have been present even though the kidney is completely destroyed. There may be a little aching in the loin, some polyuria giving rise to frequency, occasionally there may be a profuse hæmaturia, and very rarely acute renal colic. The bladder has a great resistance to infections, and bacteria may pass over it for years without giving rise to any lesion. Even when infection develops it always has a tendency to heal.

Once the bladder is involved the symptoms change. There is now frequent and painful micturition and a little urgency; a little blood may be present at the end of micturition. These symptoms are very slight at the start and may disappear for months. They generally tend to persist and to become more severe, but pain is not a marked feature in the early stages. They are sometimes made worse by the administration of hexamine. In my cases the symptoms were present for over a year; in 70 per cent before the urine was examined for tubercle bacilli. Even if the patients come for an examination as soon as the bladder symptoms appear, and the diagnoses were then made, the chances are that the disease is already advanced in the kidney.

As a rule the patients are extremely healthy. While there may be a slight loss of weight, it is rare that the patient shows any lassitude, has night sweats or an evening rise of temperature. When these are present, the possibility of a miliary tuberculosis, of a secondary infection, or some lesion in the lung must be considered. Loss of weight, lassitude, and a poor appetite suggest the onset of a uræmia. Even when both kidneys are involved, it is extraordinary how healthy these patients may remain.

The healthy appearance of those who have uncomplicated genito-urinary tuberculosis must be kept in mind when a patient has a double lesion such as urinary tuberculosis and phthisis. If there is any loss of weight, asthenia, or rise of temperature, this is rather to be attributed to the phthisis, and no improvement will follow nephrectomy.

The diagnosis is made by detecting pus and tubercle bacilli in the urine and by cystoscopy. A guinea pig should also be inoculated if there is any doubt. It is not common to have large amounts of pus in the urine; often it appears clear.

The tubercle bacilli should be sought for by a skilled bacteriologist. In a suspicious case at least three examinations should be made. If the lesion in the kidney is closed (8 per cent of my cases), no pus or tubercle bacilli may be present in the urine. These can be diagnosed only by cystoscopy.

Through the cystoscope the whole of the mucous membrane may be examined. If tubercles, a superficial ulceration, a golf hole orifice, or a retracted ureteral orifice are seen, one can be quite definite that the condition is tuberculous. This was possible in 75 per cent of my cases. If there is a closed tuberculosis, it can be seen that no urine is coming down from this side, and from the condition of the ureteral orifice or from scarring in the bladder, it may be possible to say that this is due to tuberculosis. If a 4 per cent solution of 0.4 solution indigocarmine is injected intravenously, it should appear from a normal kidney within 4 minutes. This test is not of much value if it is delayed from both kidneys as the patient may have an idiosyncracy to the drug, and its elimination is particularly interfered with if a general or spinal anaesthetic is given. But if

[1]Read before the Tuberculosis Association of Great Britain at Cardiff in April, 1933.

there is a delay in its appearance from one kidney, it is strongly suggestive of disease in that kidney, and even with an early tuberculosis the elimination of indigocarmine is impaired.

In recent years the discovery of uroselectan by von Lichtenberg has been of much help in showing up the changes that are taking place in the kidney. It will show up the outline of the calyces and of the pelvis and will reveal small cavities. It will not reveal lesions situated deeply in the kidney, unless these are large enough to deform the pelvis, nor early lesions in the mucous membrane. Since the introduction of uroselectan, an ascending pyelography is rarely necessary.

With these combined methods it should be possible to diagnose every case of urinary tuberculosis. A secondary infection may obscure the picture. The possibility of a tuberculous lesion must always be borne in mind when these cases are intractable to treatment or tend to recur.

Nephrectomy is the routine treatment for tuberculosis of the kidney in all countries of the world. The end-results are excellent if the other kidney is free from tuberculosis and its function is sufficiently good to enable it to carry on the function of the body by itself.

THE INVESTIGATION OF THE SECOND KIDNEY

The methods of examining the function of the second kidney have become so exact that it can be said that no patient should die of uræmia after a nephrectomy. This is largely responsible for the improvement in the statistics for nephrectomy; at the end of the last century, the mortality was 25 per cent, now it is 2.5 per cent. It is essential not to expect obvious signs of renal failure but to look for and to pay the closest attention to the slightest changes from the normal.

The urine from the healthy kidney is collected and examined for pus and tubercle bacilli. It has been suggested that it should be injected into a guinea pig; as one tubercle bacillus is sufficient to kill a guinea pig, this is too delicate and is, in my experience, unnecessary. If either pus or tubercle bacilli are found, the kidney must be assumed to be tuberculous. But even when the kidney is healthy, these may be present owing to a flaw in the technique of which the following need consideration:

1. As the catheter passes through the bladder, some of its contents may be collected. To prevent this a syringe is attached to the end of the catheter and sterile fluid is injected until the eyes have passed beyond the ureteric orifice.

2. The contents of the bladder may pass up the ureter alongside the catheter into the pelvis of the kidney. This will happen only if there is any tension in the bladder. While the bladder must be distended when an examination is being made, this is inadvisable when the ureteric catheter is being passed, and is not necessary if the position of the ureteric orifice was noted at the time of the examination. If the continuous irrigation cystoscope is used, the injection of fluid under very slight pressure will keep the mucous membrane clear while the catheter is being passed.

3. If the disease has involved the lower end of the ureter in its ascent to the kidney, removal of the diseased kidney is not contra-indicated. As the catheter passes up it may collect pus and tubercle bacilli from this area.

4. The presence of a catheter irritates the mucous membrane especially if it has been sterilized in formaldehyde. This seems more likely to arise in tuberculous subjects. As a result leucocytes appear and it is impossible to differentiate between these and pus cells.

It is my practice to allow the first fluid that comes out from the catheter to escape and then to collect 4 cubic centimeters in the first test tube, 4 cubic centimeters in the second test tube, and the remainder in the third test tube. Each of these are examined for pus and tubercle bacilli. If these are present in one but not in all of the specimens, the possibility of some flaw must be considered. If it is not possible to come to a conclusion from the first examination, this must not be repeated until a month has elapsed, for it is impossible to be certain that trauma to the ureter has not occurred and the effects of this may persist for some time.

If the bladder is very irritable it may be impossible to pass a catheter into the ureter. These cases formerly gave rise to considerable difficulty. Uroselectan is of great value in such a case. It is also of value if the examination of the urine from the second kidney has led to any uncertainty. Formerly in difficult cases it was sometimes necessary to catheterize the ureter four or five times. Nowadays it is rarely necessary to do this more than once.

In estimating the renal function, indigocarmine should come through within 4 minutes of its injection, the urea concentration should be above 2.5 per cent (15 grams of urea having been given 2 hours before the examination), and the blood urea should be below 40 milligrams. A normal blood urea does not signify that either kidney is functioning properly, but if it is raised, it means that both are diseased and neither can be removed. With a normal kidney, uroselectan should give a definite shadow within 3 minutes.

I have never seen a case of tuberculosis of the kidney associated with any variety of Bright's disease though there is no reason why it should not occur. The signs of this disease will be sought for in the general clinical examination that must always be carried out; its presence would contra-indicate nephrectomy.

The general condition of the patient must always be taken into account for a kidney operation is always difficult and causes shock, which is largely responsible for the mortality of 2.5 per cent. The difficulties that have to be encountered cannot be estimated until the kidney is exposed at operation, as so much will depend upon the density of the adhesions that have formed round it and where they are situated. The operation is not an emergency operation; and the surgeon must always keep in mind the question, "Is this patient fit to undergo a major operation?" There is a tendency nowadays to concentrate too much on the state of the other kidney and to ignore the general state of the patient.

CAN A KIDNEY IN WHICH NO TUBERCULOUS LESION EXISTS EXCRETE TUBERCLE BACILLI?

It is frequently stated that healthy kidneys excrete tubercle bacilli. In Cardiff I have the help of skilled bacteriologists and tubercle bacilli are not likely to be missed. Yet not one case has been sent to me in which when they have been found in the urine a definite surgical pathological lesion in the urinary tract has not been present. The cases examined are those in which a surgical opinion is required to find out if tuberculosis is present in the urinary tract and whether treatment is indicated. I am rarely asked to see those who are acutely ill of tuberculosis elsewhere or who are dying from tuberculosis itself, when lesions are apt to spring up anywhere. On comparing the accounts of those who have done research work on this it will be found that some claim to have found the tubercle bacilli in the urine in 40 per cent of those who suffer from tuberculosis; others, on the other hand, deny that they are present. There is considerable discrepancy in their results. They do not record whether they are dealing with those who have an active tuberculous lesion or whether the patients are seriously ill and in that condition in which a miliary tuberculosis is apt to occur. There is no reason why the kidneys should be especially picked out, merely because they are excretory organs. If this bacilluria does occur it means that in all tuberculous states there is a bacillæmia, i.e., a condition in which tubercle bacilli are present in the blood stream, and that miliary tubercles are apt to arise in any organ. This is rarely found except in miliary tuberculosis and in the terminal states.

In all cases of nephritis it is my practice to have the urine examined and to have a guinea pig inoculated. Yet in not one case has this been positive. The term tuberculous nephritis is again coming into use. It is uncertain what this really refers to, though it seems to correspond to the *tuberculose renale non-folliculaire* of French writers. Those who use it seem to suggest that it is possible for the tubercle bacillus to be deposited in the kidney and to give rise to a nephritis without the formation of a tuberculous lesion. I am doubtful if this does occur. A patient with phthisis can have an attack of ordinary Bright's disease, he may have albuminuria due to the toxæmia if this is acute, or to amyloid disease if chronic, or he may develop tuberculous disease of the kidney. But to suggest that tubercle bacilli can be deposited in the kidney and give rise to nephritis without a tuberculous lesion is opposed to our knowledge of the pathology of this organism in general. Though surgeons would do well to keep an open mind on this question of bacilluria due to the tubercle bacillus, it does seem that it is not a question of any practical importance, particularly if it is borne in mind that in urinary tuberculosis pus as well as tubercle bacilli must be present.

CAN A TUBERCULOUS KIDNEY LESION HEAL?

Many surgeons consider that a tuberculous lesion in the kidney will never heal, and though cases have been recorded where this has taken place, they are so rare that they can be regarded as the exception that proves the rule. Tuberculous lesions heal in all other organs and there is no reason why they should not heal in the kidney. It cannot, of course, be put at rest as urine is being continuously secreted, but this also applies to the lung where healed lesions are common. Scars are by no means uncommon in the kidney. Were these present in the lung they would be regarded as healed tuberculous lesions. It is difficult to understand why they should always be regarded as the result of emboli when found in the kidney. Tuberculous lesions here do tend to become circumscribed, and it is not uncommon to find caseous masses completely encapsulated in fibrous tissue.

But patients do not come for treatment until bladder symptoms have been present for some time and, even when the diagnosis is made as soon as they appear, the probability is that much destruction has already taken place in the kidney, and the lesion that is present is a cavity.

Once this has formed, it is rare for it to heal unless the organ collapses and the walls come together. In a solid encapsulated organ like the kidney, this is not likely to take place. In the case of a cavity in the lung, healing does not take place until the lung has been collapsed by pneumothorax or thoracoplasty. It does not matter that in one the cavity is small and in the other large; the important point is whether the organ can collapse so that the walls come together. If this can take place, there is no reason why healing should not follow. When the ureter becomes involved, there is a tendency for it to become fibrosed and to give rise to a stricture; this leads to a hydronephrosis and to destruction of the kidney which would also prevent healing. Notwithstanding these points, it is my feeling that tuberculous lesions in the kidney do at times heal and that, if one is certain that the disease is in an early stage, conservative treatment could be instituted.

In 1925 I had 3 patients, 2 men and a woman, in whom there were only slight lesions in the bladder; there was very slight delay in the appearance of indigocarmine, and the functional tests of the kidney were good. They were comfortably placed in life and with treatment in a sanatorium and tuberculin, the symptoms disappeared and there was no pus or tubercle bacilli in the urine. A cystoscopy was carried out on one subsequent occasion in each. There was again only slight delay in the appearance of indigocarmine and there were no lesions in the bladder. One of the patients died in 1928 of pneumonia, which was not related to the tuberculosis, and the 2 others were lost sight of in 1929, up to which time they had had no recurrence of the symptoms. From the start the general conditions of these patients was good, the disease in the bladder very slight, and the tests suggested that the disease in the kidney was not marked. The renal function tests give some evidence of the progress of the disease, but in this respect they are not too accurate.

Now that excretion urography is available, it is possible to estimate the changes that have taken place at the time of the examination and to note their progress with treatment. In early cases conservative treatment should be given a trial. This must not be taken to mean that this is being advocated as a routine in urinary tuberculosis as the cases in which this should be attempted are very few, and must be chosen with the greatest care. It should only be attempted when it is quite definite from the pyelogram that no cavity formation exists. I do not think I have seen more than 12 cases in which it should have been attempted: the 3 cases quoted: the 6 early cases treated by nephrectomy to which I shall refer later; 3 cases I have seen since 1930, which have not been observed for a sufficiently long period. As 365 cases of urinary tuberculosis have been seen, the proportion where conservative treatment is possible is very small.

NEPHRECTOMY

In 1926, I investigated cases that had been operated upon at least 2 years previously. It was impossible to trace half the patients. The mobilization of the population that took place during and after the War had not ceased. Of those whom I could trace I was able to examine only half. That means that with only a quarter of my patients would it be possible to know definitely what their condition was, and for statistical purposes my findings would be valueless. My experience leads me definitely to reject the statistics that are based on replies to letters. It is often difficult enough to come to a conclusion with the patient present; it is impossible when he replies to questions the meaning of which he may be uncertain and the answers to which are liable to vary according to his mood.

It is fortunate that we have the work of Wildbolz,[1] our greatest authority on genito-urinary tuberculosis, to guide us. He has investigated his cases where nephrectomy had been carried out at least 10 years before, and found that 59 per cent were alive; and with the exception of 3 they had remained cured of their urogenital tuberculosis. Many of the patients who were dead had died of some intercurrent disease. Nearly all had lost their bladder symptoms and had normal micturition. His mortality was 2.5 per cent. If no operation was done he found that 57 per cent died within 5 years. So that if the mortality of the operation does seem high, the mortality of leaving the disease eventually is much higher. Of the cases I could trace my results conformed to these.

Much has been written about the treatment of the ureter to avoid infection of the wound and the formation of a sinus. The confusion is due largely to the failure to appreciate that it is necessary to have the patient in as fit a condition as possible at the time of the operation. This should never be done immediately the tests are completed. These tests are a much greater strain than is commonly supposed and impair the general health and the power of resistance. A medical man I know well had his gall bladder investi-

[1] Wildbolz, Hans. J. Urol., 1929, xxi, 145; Handbuch der Urologie.

gated by the usual tests; at the end of 2 weeks he was surprised to find that he had lost 10 pounds. For the patient, these examinations are very trying and must be looked upon as a series of minor operations. He requires time to recuperate and it is better to wait for at least 1 month during which time he should receive treatment in a sanatorium. Even a short visit to the seaside makes a big difference. A little care taken at this time will save many months later on. Since I have carried this out none of my wounds have broken down and no sinuses have persisted. It may be said that there is a tendency for the second kidney to be involved during this time but this is theoretical rather than practical, for the extension of urinary tuberculosis is not a rapid process; it is a matter of years not months.

After the operation, sanatorium treatment should be carried out for at least 6 months. There is no difference between surgical and medical tuberculosis, and the need for sanatorium treatment is as imperative in one as in the other. Unless this is possible, I am reluctant to operate for tuberculous disease.

When investigating my cases certain points of interest arose.

1. So often it was found that the patient did well when at the sanatorium, but the disease recurred when he took up his former work. If he was able to change this for a more suitable employment he remained cured. Formerly this was possible. With unemployment rampant, it is only the fortunate patient who can now do this. Consequently, the statistics for the treatment of tuberculosis are bound to suffer.

2. One patient who had had the kidney removed was doing well until she married a year later and became pregnant. She would not consent to an abortion. She stood the pregnancy well but during the puerperium the tuberculous disease flared up, and she died of miliary tuberculosis. This is the only case I have come across where a patient who has had a tuberculous kidney has become pregnant. Three of the patients married but had no children. It was somewhat doubtful whether the trauma that might be associated with coitus might not injure the lesions in the bladder, but these 3 patients were none the worse.

3. The question that is sometimes asked is: In genito-urinary tuberculosis may not coitus lead to the development of the disease in the partner? Though this was to be expected, I have not so far come across a case.

4. I was surprised to find that where nephrectomy showed an early lesion in the kidney, the patient rarely did so well. Four of the deaths were in these patients and took place within a year, two from tuberculous disease of the lung which was not detected at the time of the operation and was probably not present, as one did well for 4 months and 1 for 6 months before the first lung symptoms appeared. One died of acute miliary tuberculosis coming on 8 months after the operation when the convalescence had seemed normal. One died of tuberculosis of the second kidney; there had been no improvement in the bladder symptoms at any time after the operation. I could recollect removing the kidney in only 6 cases in which the lesion was small, and 4 of these had died within a year. This was quite a surprise as I had been advocating early diagnosis with a view to early removal of the kidney. Yet I am now quite definite that these cases do the worst.

The conclusion now come to is that it is bad surgery to try to cure a patient with early tuberculosis by removing the diseased organ.

GENITAL TUBERCULOSIS

While great advances have been made in our knowledge of tuberculosis of the urinary tract, a field in which diagnosis has become a fine art, this cannot be said of genital tuberculosis, for its pathology still remains uncertain, the diagnosis is as difficult and as inexact as it was 30 years ago, and the methods of treatment that are advocated are not consistent.

The views that are held are most confusing and the position is comparable to that of urinary tuberculosis in the days before cystoscopy and catheterization of the ureters were undertaken. At present it is difficult to obtain the secretion of the testes, and impossible to separate that secreted by each. Nor has any substance that can be excreted by the seminiferous tubules and that renders them opaque to X-rays been introduced. The introduction of such a medium should be possible, if those interested in the chemical side of medicine would give it their attention. When this substance is available, a solution of the problem is likely.

A nodule in the epididymis might be due to tuberculous disease or to a bacillus coli infection which is much commoner than is supposed. If the nodule clears up under treatment the diagnosis will always be in doubt. Should it break down to form a sinus, it is not necessarily tuberculous, for staphylococcal infections are seen similar to those that are found in the kidney and when they occur usually suppurate. It is often not possible to come to a definite conclusion from

the clinical findings alone. In only 30 per cent of my cases in which there is extensive tuberculous disease of the prostate are lesions present in the prostatic urethra that can be detected by the cysto-urethroscope, and many of these cannot be distinguished from those due to ordinary infections. When the disease is limited to the testis, they are extremely rare. It is only when ulceration takes place into the bladder or prostatic urethra that pus and tubercle bacilli are found in the urine. It is possible that examination of the semen might give more definite results but this is rarely possible. After massage of the tuberculous prostate, the amount of pus that can be expressed is not great and it is not always easy to distinguish between the cells of the prostatic secretion and pus cells. Tubercle bacilli can be found in only 25 per cent of the cases and the inoculation of the prostatic secretion is positive only in a few cases more. Massage of the prostate should not be carried out as a routine or on more than one occasion, as trauma of a quiescent tuberculous lesion may light it up.

Tuberculosis of the testis may begin acutely. This was the method of onset in 5 per cent and in 3 of 4 the inflammation subsided and the disease became chronic; in the other, before this took place, an abscess formed and discharged. Usually it begins very insidiously as a nodule in the epididymis. This may remain quiescent for years, but unless treatment is carried out the tendency is for it to extend and to break down and to form a sinus. In the majority of cases these ultimately heal. It is extremely rare for an abscess to arise in the vesicles or prostate. Apart from cases of genital tuberculosis in boys at puberty which run a very virulent course, I have seen none. In 35 per cent of my cases, nodules are present in both testes at the time of the examination, and in the remainder, it develops in 7 of 10 within a year. The disease usually runs a chronic course and having involved two or more areas in the genital tract tends to subside. In some cases it extends locally giving rise to multiple sinuses and it may be necessary to remove the testis. This has taken place in 5 per cent of my cases.

In a proportion of the cases which varies from time to time, tuberculous lesions may arise in other organs such as the lung, or death may take place from miliary tuberculosis or from tuberculous meningitis. To prevent these complications and to rid the patient of a focus of disease, removal of the testis was carried out as soon as the diagnosis was made. It had little effect, so far as the subsequent course of the disease was concerned, and extension to the second testis was just as frequent. Lesions broke out in the lung, and probably after no operation for tuberculosis are acute miliary tuberculosis and tuberculous meningitis so apt to arise. This was attributed by some to a loss of the internal secretion, and they have advised the removal of the epididymis alone. Others have considered it to be due to the disease not being completely eradicated and have advised the more extensive operations. These have not found favor in this country and the majority recommend conservative treatment. It is strange that surgeons who are quite definite about the removal of a kidney for urinary tuberculosis fall into such widely divergent schools over the treatment of genital tuberculosis.

THE OPERATION OF EPIDIDYMECTOMY

The object of this is to remove the diseased part but to retain the body of the testis which gives rise to the internal secretion. To prevent extension to the other testis the opposite vas deferens is ligatured at the same time. It is claimed that the internal secretion increases the physical and mental vigor, as a result of which the patient is able to overcome the disease. In addition a full scrotum would be a comfort and a moral support to a man.

A strange position arose. In the case of the kidney, notwithstanding that it is a vital organ, most surgeons are agreed that a partial nephrectomy should never be done, as if any part of the disease was left the operation would fail. No one would sanction opening the kidney, as this would infect the whole of the wound. Yet a partial orchidectomy, for that is what epididymectomy amounts to, is advocated by them just to preserve an internal secretion. It usually means that a part of the disease is left behind and a tuberculous organ is incised in an open wound. It is forgotten that in operating for tuberculosis it is not so much an organ that is being operated upon as a particular disease; and the principles on which the operative treatment are based should be the same for one as for the other.

At one time I did the operation but gave it up as a sinus often resulted when none had been present before, and the end-results were worse than if the disease had been left alone. My attention was also drawn to cases in which men had had both testes removed in whom there was no impairment of mental or physical vigor and no tendency for the disease to spread. If this was the case when both testes were removed, the removal of one should have no effect. In addition, the nodule that was present in the scrotum after the operation of epididymectomy would be of little

comfort to a full blooded man; and some asked for it to be removed when a sinus persisted. Therefore if an operation upon the testis is indicated it is better to remove it altogether.

The symptoms that persist after removal of a tuberculous testis are not due to the want of an internal secretion, for they are not seen if a testis is removed for malignant disease or as the result of an accident. The prostate is a very sensitive gland which is richly supplied with nerve fibers. When it is the seat of tuberculous disease, abnormal sexual sensations are set up and, if the health is poor, these are felt all the more. If the testis has been taken away these symptoms are attributed to its loss; if no operation has been done, to its diseased state and a firm conviction that they will disappear if it is removed; if an epididymectomy has been done, to the part of the testis that has been left behind or to a sinus that persists with the firm conviction that they will disappear if this is removed. Really these symptoms are due to the inflamed state of the prostate and will clear up as the local conditions and the general health improve. Similar symptoms are present in chronic prostatitis due to gonorrhœa.

CONSERVATIVE TREATMENT

This is the school to which most surgeons come after they have experimented in the operative treatment of genital tuberculosis. It is realized that with rest, sanatorium treatment, tuberculin, and solganol, the disease subsides and a cure results. If a cavity forms, a little external pressure can cause it to collapse, and the end-results are better than with any form of operative treatment. If an abscess forms, the pus is aspirated. If the testis becomes disorganized or if it causes the patient discomfort, it may be removed. With conservative treatment the sinuses tend to heal and if sanatorium treatment can be arranged, the spread to the other testis may be avoided, and lesions elsewhere are not so liable to arise. Occasionally tuberculous disease may arise in the lung or death may occur from miliary tuberculosis or tuberculous meningitis. It must not be assumed that if the testis has been removed these would not have occurred. Experience teaches that with the operative treatment they are more common.

When investigating the end-results of cases of genital tuberculosis, it is impossible to come to any conclusions for we are still uncertain of its pathology. It leaves the definite impression, however, that with conservative treatment the end-results are better than when operative treatment is carried out as a routine. Two points, however, need special consideration. In genital tuberculosis it seems to be thought that as the testis is a small organ the effects of the disease can only be small, and the same care is not taken at the start as with a case of phthisis. Nothing could be more fallacious for, though of course the presence of tuberculosis in one organ may be more dangerous than in another, the same general treatment is required from the start. Sanatorium treatment is as much needed for genital tuberculosis as it is for phthisis. It is difficult to fix the testis with strapping; but this should be attempted when the patient is kept in bed. A suspensory bandage should be worn when he is up.

Because of the superficial position of the testis, tuberculosis is diagnosed at a stage long before it is possible to do so in the case of an internal organ such as the lung or kidney, for here a nodule in this stage would not be detected. In the case of the testis early tuberculosis is being treated. In the case of urinary tuberculosis, even if the diagnosis is made as soon as symptoms appear, the disease has generally been present in the kidney for some time and established tuberculosis is being treated. The treatment of one is very different from that of the other.

PRINCIPLES IN THE TREATMENT OF TUBERCULOSIS

When a tuberculous lesion arises in an organ it may be regarded from two points of view: either as the advance of a disease or as the resistance of the body to an infection. It may be an advantage to a patient to have a tuberculous lesion in an unimportant organ if the tissues can control its progress. By that it is not suggested for a moment that a man with a tuberculous lesion is better off than a healthy man, but that it is better for him to have a tuberculous lesion in the testis, if it is the means of preventing one in the lungs or meninges.

Tubercle bacilli must come from some focus in the body or from some source outside. In a healthy person these will be destroyed by the antibactericidal properties of the blood. If the resisting powers of the body are impaired destruction of the bacilli does not take place and they live and grow. If the resistance is very poor, an acute miliary tuberculosis may develop. On the other hand, if the bacilli are deposited in an organ and a tuberculous nodule arises, this nodule means that the progress of the disease is being resisted locally, for with the miliary disease none is formed. If the nodule is composed of fibrous tissue, the resistance is good and the disease is being controlled and a cure may follow. If the nodule is composed of caseous matter, the out-

look is not so good; if it is composed of pus, the resistance is low and the disease is extending; but even pus is less serious to the patient than the rapid miliary spread of the disease. At the same time as the disease is developing locally, minute doses of toxins are being absorbed into the blood and all the tissues of the body respond by producing antibactericidal bodies and the powers of resistance to the tubercle bacilli is being raised throughout. Not only does this enable the tissues to deal effectively with the infection, but the blood is also able to deal with bacilli that may be passing into it from the original source. If the disease is localized, it is a mistake to remove it too soon. If this is done the condition that is causing the antibactericidal properties of the blood to the tubercle bacilli to be raised is taken away. As a result, any bacteria coming from the original source will not be destroyed and may grow in the tissues giving rise to miliary tuberculosis or a lesion in some less favorable site, such as the lung. It is on account of this that tuberculosis may arise in another organ after an operation and not because bacilli are dispersed from the diseased part at the time. As it may thus be the means of helping a patient to increase his powers of resistance, it can be said that it may be advantageous for a patient to have a tuberculous lesion developing in an unimportant organ if the tissues are able to control it.

Some surgeons would advise removal at an early stage. They claim that by this they have cured the patient of tuberculosis. They have done no such thing, for the development of a tuberculous lesion is really the manifestation of a lowered general resistance to the tubercle bacillus. which will persist after the operation. Even if the tuberculous lesion is removed it is not possible to say when the wound has healed that the patient has been cured as could be said of the removal of scar tissue, for the impaired constitution will remain. At the most an operation can place the patient in the position he was in before the onset of the disease, namely that if the bacilli escape into the blood a lesion will arise in an organ in which they are deposited. If the bacilli come from an internal focus, it is impossible to prevent their entry, and if they come from some external source, this may be difficult to control. After the operation the patient is sent to a sanatorium to improve the general health, for it is known that when this is good the powers of resistance to disease are also good. The race is determined by whether the general resistance of the body can be raised before bacteria pass in and the disease breaks out elsewhere.

However, when the disease has been present for some time, this means that the powers of resistance have been raised. Otherwise it would have extended, but local conditions cannot be dealt with because of the presence of cavities or of much fibrous tissue. Consequently, removal of the focus may be of advantage to the patient. There will be little danger of the disease breaking out elsewhere as the resistance will have been raised.

This line of reasoning explains why the removal of a tuberculous testis may be followed by disastrous results and why the removal of a tuberculous kidney is followed by excellent results. For with the former early tuberculosis is dealt with; with the latter, even if diagnosis is made as soon as symptoms appear, it is probable the disease is of some standing.

CONCLUSIONS

The surgeon, as he approaches a case, will be faced with the following points:

1. What is wrong with this particular patient? A diagnosis should always be made in urinary tuberculosis. In genital tuberculosis it is often impossible.

2. What shall I do to put this patient right? In tuberculosis, it must be borne in mind that an operation is only part of the treatment. It is essential to have the patient in as fit a condition as possible both at the time of and for some months after the operation.

3. Is an operation indicated for this particular disease? For urinary tuberculosis it is the treatment of choice; for genital tuberculosis it is rarely needed.

4. Is this the right time at which to operate? A diagnosis should be made as early as possible to put the patient under those conditions that help to build up his resistance. An operation that is of advantage for established disease may do harm if it is done at too early a stage. This explains the different results that are obtained for the operative treatment of urinary and genital tuberculosis.

5. Is this the right type of patient upon whom to carry out this operation? If the patient's constitution has been impaired by a poor upbringing, little can be done to put this right. If the disease is removed, it only breaks out elsewhere. If he has to return to an environment where the home conditions are bad, the disease is likely to recur. In a disease such as tuberculosis these factors must receive consideration.

DIRECT HERNIA: A RECORD OF SURGICAL FAILURES

EDMUND ANDREWS, B.A., M.D., F.A.C.S., AND ARTHUR D. BISSELL, M.D., CHICAGO
From the Department of Surgery, The University of Chicago

THIS paper is written as a protest against the enormous amount of surgery being done for the correction of a condition which is in the vast majority of cases a perfectly harmless one and can scarcely be called a disease. The surgery stands even in a worse light when one faces the undoubted fact that in about one-fourth of the cases the patient is made definitely worse than he was before.

MAGNITUDE OF THE PROBLEM

The magnitude of the problem can be stated with singular accuracy on account of the enormous number of examinations made by various recruiting agencies and draft boards. Such figures are available in many of the countries of Europe back to the time of the Franco-Prussian War, our own Civil War, and finally the Great War. In these latter statistics one may consult a tabulated record of 2½ million men examined between the ages of 21 and 31, 2.08 per cent of whom had hernia. If these figures were applied to the population as a whole, it would be apparent that there were in the neighborhood of 2¼ million sufferers from hernia in the United States. However, when one considers the relative frequency of hernia in the different age groups, it at once becomes clear that the group under ages 21 to 31 shows the least liability to hernia formation, in that hernia is very much more common in the very young and in advanced middle life and old age. The figures in the very young are of no importance to us in this study as direct hernia is practically unknown in infancy and youth. Statistical reports show that hernia is about 50 per cent more common in middle and old age than in the draft age. Thus if the numbers of the various age groups of population are kept in mind, it becomes clear that there are probably about as many men over 20 alive with hernia as there are below.

From these data one may calculate the number of sufferers from direct hernia in America. In various clinical reports about one herniotomy out of five is for direct hernia. Women and children in whom hernia is always oblique must be omitted from the series. This leaves us then with an estimation that there are about a quarter of a million individuals with direct hernia and it is difficult to exaggerate the importance of any problem involving such enormous numbers.

PATHOLOGY

A direct inguinal hernia is such a totally different condition from the oblique type that it is unfortunate that the term "inguinal" seems to group them together. The direct hernia is a simple dome-shaped bulging of the peritoneum and transversalis fascia into the floor of an inguinal canal which is imperfectly formed. It has no relationship to the cord or to weakness caused by the descent of the testes and lies medial to the deep epigastric artery. In other words, it does not come through the internal ring.

In most animals, Poupart's ligament runs much more nearly parallel to the longitudinal axis of the body than it does in man and the space between Poupart's ligament and the rectus sheath is a narrow one. In man, however, the wider flare of the pelvis separates these two structures and in the normal individual this defect is filled in by the conjoined tendon and internal oblique muscle. The latter structure takes origin from Poupart's ligament just above the internal ring and arches medially inserting normally into the pubic bone quite close to the lower end of Poupart's. When the anatomy is of this type, it is obvious that there is no hole in the floor of the canal through which a direct hernia could pass and also that the contraction of this muscular aponeurotic sheet would approximate it to Poupart's ligament and thus act as a sphincter by closing the canal.

In a large percentage of individuals, however, the lower borders of this muscle are markedly deficient and in this class fall the sufferers from direct hernia. The aponeurotic or fibrous portion of the insertion is frequently completely absent and the muscle itself, although its origin is normal, instead of having an almost common insertion with the rectus into the pubis, inserts at a variable distance from the pubis on the lateral edge of the rectus sheath. This muscular deficiency creates the so called inguinal triangle which is much more important than Hesselbach's triangle as it represents the exact hole through which the hernia emerges. The inguinal triangle is bounded below by Poupart's ligament, above by the internal oblique muscle and medially by the lateral border of the rectus sheath. This leaves then, a wide open space the floor of which is made only of peritoneum and transversalis fascia, producing an ideal spot for hernia to occur.

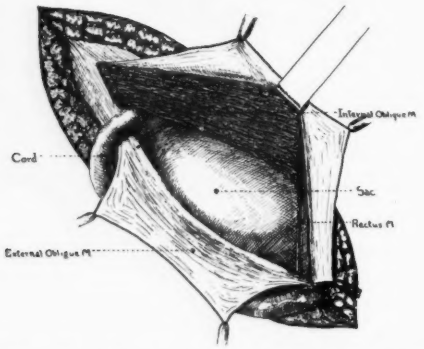


Fig. 1. Direct hernial sac. A simple bulging forward of the floor of the inguinal triangle. This triangle is bounded below by Poupart's ligament, above by the internal oblique and medially by the rectus. The space is wide and the bulging dome-shaped, not allowing any possibility of strangulation.

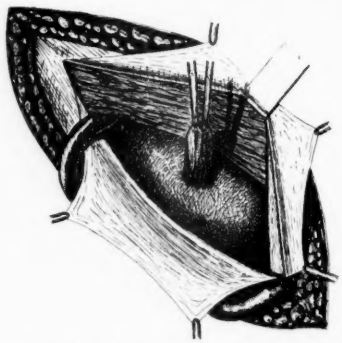


Fig. 2. Direct hernial sac with diverticulum. The fascia covering the peritoneum gives way or is congenitally imperfect and the result is an additional bulge in the floor of the canal. There is generally a sharply defined neck to such a diverticulum.

It is not only the actual hole in the abdominal wall that is important, however; the loss of the mechanical advantages and of the possibility of sphincter action by such a mechanism is obvious. An internal oblique and conjoined tendon which insert normally can approximate themselves to Poupart's ligament by contraction while the abnormal or deficient ones cannot possibly have such an action. Inserting high up on the rectus sheath as they do, contraction of these muscles cannot pull the rigid structures together and all possibility of a sphincter defense is ended. I have measured this in a series of twenty direct hernias and found that the average amount of rectus sheath that bordered the inguinal triangle was 5 centimeters. In other words, the average direct hernia has a lack of 5 centimeters of important tissue and this is certainly its reason for existence.

The sac that bulges through this hole is of course dome-shaped. The hole is very large and the peritoneum and transversalis fascia simply bulge forward into it until they encounter the external oblique aponeurotic sheath. Such a sac has no neck and simply represents a wide pocket whose breadth generally far exceeds its depth. As one opens the inguinal canal by section of the external oblique aponeurosis and retracts the cord, this bulging at once becomes evident (Fig. 1). The wall of the sac is made up of peritoneum and covering this is a layer of white, fibrous, connective tissue the strength of which is exceedingly variable. This layer of white fibers tends to become hypertrophied in the case of a direct hernia. It frays out as it passes under Poupart's ligament into the pelvis and becomes very thin. As one dissects up under the internal oblique, there is a very much stronger fibrous element encountered.

This represents the typical pathological finding of a direct hernia. There is, however, another complication which may take place in a small minority of cases. This complication consists in the finding of a hole, generally sharp and discrete, in this fascial layer and a bulging into this hole of a diverticulum of peritoneum which is generally exceedingly thin walled. The hole through which these diverticula emerge is in most cases quite small and the diverticula may reach the size of one's thumb or even larger (Fig. 2). I have found this secondary hernia to take place in less than 10 per cent of direct hernias but it is something that one must always keep in mind as its presence completely changes the prognosis of the case and increases the possibilities for such disasters as strangulation or incarceration. There are two definite types of these diverticula. The first is that which rises within the canal. The second is that which occurs when the direct hernia bulges up to the external ring and, as a rare complication, a diverticulum is formed in this area which sticks out through the ring. It is the experience of most surgeons that when a direct hernia does emerge through the external ring in this manner it generally bulges forward or curls up on the abdominal wall and does not have the tendency to descend into the scrotum as does an oblique hernia. Of course the presence of such a diverticulum is a serious matter and its narrow neck may act the same as the internal ring of an oblique hernia and produce constriction of the herniated contents.

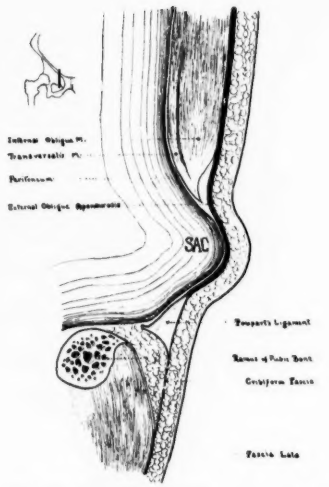


Fig. 3. Sagittal section of direct hernia. Note the wide mouth to the sac. Its very size prevents its passage out through the external ring. Such a condition is nearly always made possible only by the absence of the lower fibers of the internal oblique.

Whether these diverticula are congenital or acquired, it is impossible to state although I know of no embryological mechanism which could possibly produce them. The fact that they are not uncommonly reported to present through a well developed conjoined tendon forces one to admit the possibility of a congenital as well as an acquired origin.

SYMPTOMS

Pain, as a symptom of uncomplicated direct hernia, has in my experience been exceedingly rare. The more one studies hernias of any type, the more one feels disinclined to attribute any symptoms to them. Chronic indigestion supposed to be caused by hernia has in my experience proved very disappointing as it generally persists after the hernia has been surgically cured. This applies to indirect hernia and must be even more true of the direct type. While it is theoretically quite possible that the passage of the viscera into an oblique sac might cause symptoms at first, it is equally true that in the experience of the vast majority of surgeons these symptoms do not occur. In at least 90 per cent of all hernia cases, pain is totally absent: a most striking evidence of this fact is the large number of hernias found incidentally in routine physical examinations. A doctor finds a hernia oftener than a patient does.

The degrees of distention and tearing necessary for the passage of viscera into an oblique sac is

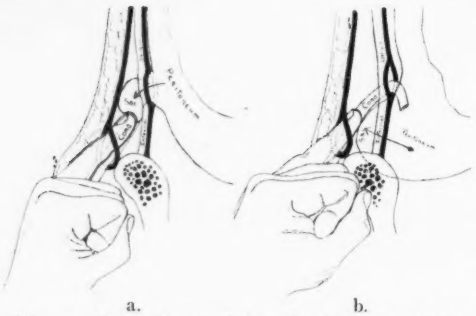
Fig. 4. Methods of inserting finger into the external ring so as to bring the ball of the finger and not the nail against the floor of the canal. This often permits one to diagnose before operation the type of conjoined tendon one is going to encounter.

nowhere near equalled in the case of the bulging which occurs with the formation of a direct hernia. In the latter no enlargement of the sac or of the surrounding structures is necessary to allow viscera to fall into it. This probably explains the undoubted fact that practically all direct hernias are absolutely painless. It is perfectly obvious from our knowledge of the anatomy of such hernias that there could be no other symptom but pain arising from them, so it is unnecessary to carry our discussion of these symptoms any further. The hernias are never large enough to give the "gone" feeling which occurs when a large oblique sac is suddenly filled and it is equally obvious that any effect whatsoever on the intestines or abdominal contents of such a sac is impossible.

PROGNOSIS

It is exceedingly difficult to quote exact figures as to the prognosis of direct hernia on account of the fact that too many of them have not been diagnosed before operation. However, certain facts are obvious. The first is that the shape of the sac makes strangulation or incarceration impossible. It is wider than it is deep and presents no more danger than any shallow pockets in the abdominal walls (Fig. 3). It is no more liable to cause adhesions to its inner surface than a dozen other similar spots in the normal abdomen. It is perfectly clear that unless a secondary diverticulum is present the prognosis must be nearly 100 per cent safe. Even if a diverticulum is present strangulation is almost unknown. Neither of the authors have ever seen such a case; nor is there any record of one in the record of The University of Chicago Clinics, 85,000 patients, or of St. Luke's Hospital, Chicago, last 100,000 cases.

The direct hernia cannot grow to large size. Its mass is far too great to permit it to pass through



a. b.

Fig. 5. Finger in canal invaginating scrotal skin. a, Oblique hernia—impulse comes down in axis of canal. b, Direct hernia—impulse comes from floor of canal.

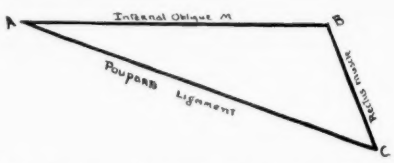


Fig. 6. The inguinal triangle. In order to obliterate this triangle surgically it is necessary to bring point *B* down to line *AC*. It is obvious that the entire pull of the rectus muscle is applied to prevent this. Such a closure can be made only by applying tension that augurs badly for the permanence of the result.

the external ring except in cases of the most extreme dilatation of the ring. The actual statistics of many clinics show that the finding of a complete uncomplicated direct hernia is a real rarity. The pillars of the external ring are very strong and the ring is not more than one-tenth the size of the hernia and it is perfectly clear that only in the most exceptional case will the ring be torn sufficiently to permit any subcutaneous herniation. In a recent article summarizing the result of 654 cases of strangulated hernia, only 18 were direct. This makes it clear that in any given case of direct hernia the danger of strangulation is practically nil. Furthermore, as I will show later, I believe that all cases of strangulation must of necessity occur in the type in which there is an associated secondary diverticulum and I will also show that this type may be diagnosed in advance or at least diagnosed as oblique hernia and thus separated out from the harmless type.

It is clear then that we are dealing with a condition which does not cause pain, which does not tend to become worse, and in which involvement of the gastro-intestinal tract is a great rarity, and I propose to deny categorically that direct hernia is a disease at all; we feel satisfied that it is a harmless condition unless the rare complication of secondary diverticulum of the sac occurs.

DIAGNOSIS

In view of the facts already stated the differential diagnosis between direct and oblique hernia assumes a very great importance although it has often been assumed that such a diagnosis cannot be made. It has, however, been my experience that it can be made in a very high percentage of cases if adequate care is taken. Certain facts may be tabulated that will assist in this diagnosis.

1. All women and children may be excluded as its rarity in them is extreme. It is also rare in men under 25 but it is not safe to be dogmatic about them as it is not so exceedingly rare as in women or children.

2. Scrotal or complete hernias may at once be excluded, since, as we stated above, direct hernia does not emerge from the external ring.

3. Irreducible hernia may be excluded since the incarceration of a direct hernia is to all intents and purposes impossible.

4. Inspection generally shows the bulging to occur near the pubic spine and not over the internal ring as is the usual case in an oblique hernia.

5. Direct hernias are reduced *instantly* on reclining and the bulging recurs with equal suddenness if the patient strains in the recumbent position. This differential point is based on the fact that the neck of the sac is so wide that any abdominal pressure is communicated instantaneously to the entire wall, whereas, in oblique hernias, time must be given for the omentum or gut to pass through the internal ring which is generally narrow and to reach the different portions of the sac to distend it. If there is the slightest delay in either the appearance or disappearance of the hernia on changes of intra-abdominal pressure, it is perfectly clear that the hernia is not a direct one. Besides this, direct hernia will always appear when the patient strains while in the recumbent position whereas many oblique hernias require considerable straining and coughing to bring them out in this position.

6. Most direct hernias are double with the two sides nearly the same and any totally unilateral hernia is almost certainly oblique.

7. Careful examination of the canal in both the erect and recumbent position is important. And it is equally important that the examining finger be introduced into the canal in such a manner that its soft parts, which have the more delicate powers of perception, instead of the fingernail, may be pressed toward the conjoined tendon and the floor of the canal. This may be achieved in the follow

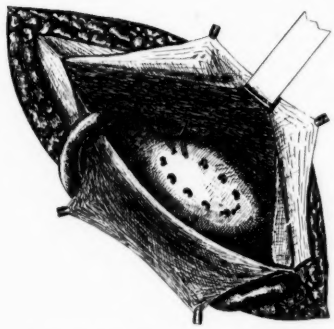


Fig. 7. A small bulging may often be flattened by a single pursestring suture.

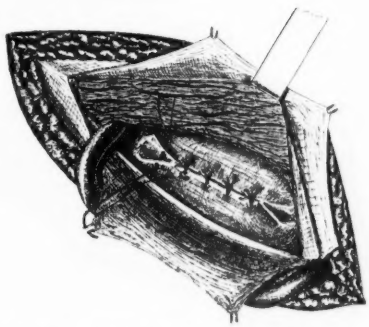


Fig. 8. If the bulge is large, a running stitch inverting the floor of the canal into itself is better.

ing manner (Fig. 4): The patient stands in front of the examiner, who uses his left hand for the examination of left canal, with the palm toward the patient and the small finger inserted into the left inguinal canal. When the right canal is examined, the right hand should be used. If one is careful, especially if the patient is recumbent, one may feel the conjoined tendon or its absence; and the findings of a lax floor of the canal so that the finger may be pushed deeply posterior, are suggestive at once that the hernia is a direct one.

8. When the patient is asked to cough with the examining finger in the canal, the indirect hernia is felt to come from above and laterally downward and to tap the finger on its tip just as if another finger was reaching down to touch it. This is indicative of the sac being an oblique one with the impulse running down in the axis of the canal. In the direct type the findings are very different. The impulse occurs from the floor of the canal and pushes the finger outward. It is diffuse and wide and no finger-like projection is felt touching the examining finger.

9. The rare cases of complete direct hernia may often be differentiated from the oblique type in that they tend to bulge forward or curl back onto the anterior abdominal wall, instead of passing directly into the scrotum.

It has been my experience that if these points are kept in mind the uncomplicated direct hernias may be diagnosed in the vast majority of cases without opening the canal. It has also been my experience that in practically all cases where I have made the diagnosis of oblique hernia and have therefore advised operation, I have found a secondary diverticulum of the sac. Since these patients present definite surgical indication, no harm has been done by the mistaken diagnosis.

INDICATION FOR OPERATION

From the above it is quite clear that we are dealing with a condition which is in a majority of cases harmless. The uncomplicated direct hernia without a sac or diverticulum can cause no symptoms except pain and this is as above stated, a rare finding. If such conditions as strangulation, incarceration, growth of the hernia and the possibility of its becoming unmanageable do occur (in the cases which are complicated by the presence of a diverticulum of a dome-shaped sac), as was stated in the section on "Diagnosis," these cases will practically always be mistaken for indirect hernia.

Therefore the indications for operation in the uncomplicated direct hernia may be expressed in a single word: it comes down to the one element—does the hernia cause *pain?* Only hernias causing pain should be operated upon. Any of the other symptoms or complications of the hernia will make it appear to the examiner that an oblique

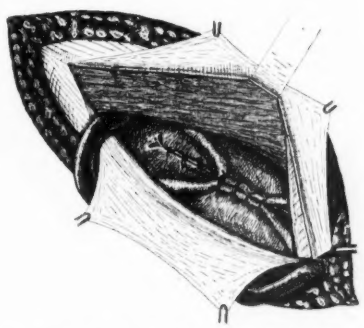


Fig. 9. A second inversion stitch is necessary in many cases to give a firm floor.

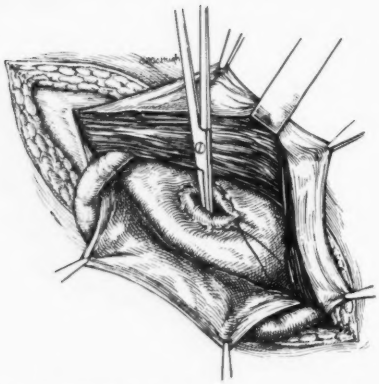


Fig. 10. A diverticulum should be inverted and its neck closed with one or two stitches. Diverticula usually have small necks and few stitches are needed. The edges of the hole through which they come are often well marked and may be seized in clamps and held up.

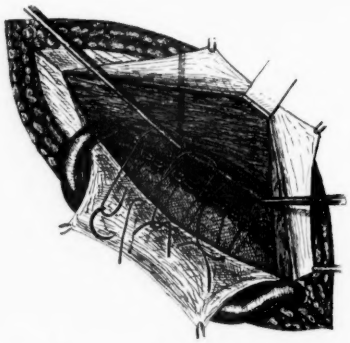


Fig. 11. The transversalis fascia is quite freely movable and may be pulled down without much tension. If the floor of the canal is still weak after the bulge is flattened, it is well to sew the fascia to Poupart's ligament. If the stitches are placed above the other suture lines, the weakened lower portion of the fascia will be pulled under Poupart's ligament.

hernia is present, and these, of course, have their own indications.

This element of pain must also be carefully evaluated. It is a common experience to find a patient who has never known that he has a hernia to complain of pain or a feeling of weakness as soon as he is informed that a hernia is present. The procedure should then be to explain to him the harmlessness of his condition and tell him to go about his business and thus assure oneself that the pain was not caused by worry and consciousness of a defect. It has been my experience that this is the case most of the time.

One of the most unfortunate aspects of the problem is the medicolegal one. Many of these patients come to the surgeon because they have been refused employment by some corporation on account of the hernia. Assurance by the surgeon that the hernia is harmless and should not be operated upon is useless, as that will not in many cases get the job for the applicant. This is due in part to the hesitancy of the examining physician to recommend the acceptance of the applicant, when many others are available who have no direct hernias. It has been my experience, however, that most examiners for corporations are keenly alive to the situation, but are tied hand and foot by legal restrictions. The normal course of events is that such an applicant should sign a waiver for any future difficulty with the hernia, but numerous court decisions in many states have been handed down to the effect that such a waiver is not legal. Any dishonest applicant may claim that his hernia is made worse by his occupation and get compensation for it, even though it has been shown to have been present at the time of his employment. The number of such malingerers is so great that few companies dare take the risk. Furthermore there is the very real possibility that the worker may develop the diverticular type. This, while not common, occurs often enough to raise important financial questions, particularly in a disease as common as hernia.

OPERATION

Opening the canal. The incision in the aponeurosis of the external oblique should always be made at a considerable distance from Poupart's ligament, as in these hernias the overlapping of the aponeurosis is indicated whenever possible. The cord should then be elevated from its bed together with all its coverings, in order adequately to expose the floor of the canal, where the sac will lie. Dissection of the cord in its bed can do no good in this type of case, as presumably at least, no sac will be found. Furthermore, in closure, the stitches should always be placed beneath all the cord structures. Especially careful clearing of the deeper structures about the proximal end of the cord is important in order to expose the deep epigastric vessels. Stitches must be placed in this region and the vessels should be found in order to avoid injuring them.

Dissection of the cord. It is important to remember that direct and oblique hernias very commonly coexist and the mere fact that a surgeon finds a direct hernia does not mean that an oblique one is not present. The cord should be

dissected apart near the internal ring in every case and a careful search made for an oblique sac. A surprisingly large number of recurrences following direct hernia are of the indirect or congenital type, and it is perfectly clear that these have been due to the surgeon's overlooking a sac which was there at the time of operation.

The internal oblique. A theoretical consideration of the mechanics of the inguinal canal which is deficient to such an extent that a direct hernia may appear, reveals at once the futility of the ordinary Bassini type of operation. It is the conjoined tendon which is relied upon in this operation to build up the floor of the canal, and when it is missing the mechanics are so entirely different that they must be carefully studied. In the accompanying diagram it may be seen that any attempt to bring the conjoined tendon or internal oblique muscle *AB* down to the line *AC* (Poupart's ligament) (Fig. 6) brings with it the necessary corollary of attempting to approximate points *B* and *C* on this line. In the ordinary inguinal hernia in which the conjoined tendon inserts down near Poupart's ligament, this may be quite possible. In the type under consideration, however, it is perfectly clear that if the point *B* is made to coincide with point *C*, the entire pull of the rectus muscle is applied to separate them again and in order to accomplish such a purpose it would be necessary to shorten permanently the rectus muscle by the distance of line *BC*, and our common sense tells us at once that this is a hopeless task. The entire pull of the muscle or at least 90 per cent of its fibers are constantly applied to restore the anatomy to its original condition and it is idle to hope that, even if we can temporarily shorten it up in this manner, our stitches will hold permanently.

The result of such stitching is that the grosser structures more or less rapidly resume their former positions after the stitches dissolve. There may be a loss of a centimeter of the edge of the rectus sheath or the conjoined tendon causing a slight enlargement of the inguinal triangle. This in itself is not serious, but in addition it must be recalled that usually some of the deeper tissues have been included in the stitches. When these stitches pull loose, there result small holes in the remains of the conjoined tendon or the transversalis fascia and into these holes the peritoneum bulges, making one or more diverticular hernias. Often a large gap in the floor of the canal is created by our stitches in a spot where there was previously only a bulging. It is evident that these new hernias which have a very small neck to the sac bounded by rigid walls would be much more liable to cause trouble than the condition for which the operation was done. This theoretical possibility is backed up by figures from many clinics indicating that recurrent hernias are especially liable to strangulation. Therefore it is not logical to assume that we may as well have a try at such a hernia; the worst that can happen is to leave the patient as he was before. The truth is that in cases of failure (25 per cent) the patient is left very much worse than he was before.

Use of transversalis fascia. Therefore new structures have to be sought for accomplishing our purpose. In the absence of the conjoined tendon we have left only the upper fragment of the external oblique aponeurosis to build the floor of the canal such as is used in the typical Andrews imbrication technique, and it is clear that this should be done in every case of direct hernia in which the fibers of the external oblique are not so weakened that it would be futile.

Even with this type of operation, although the external oblique may be then under the cord, it is idle to hope that it is really closing the internal ring and besides, it cannot be made to lie deep enough in the canal to close it properly at its upper and inner end. The one substance left which is of any value is the fascial envelope of the abdomen, the endo-abdominal fascia, and it is in the direct hernia that the most use can be made of this structure. As has been described at greater length in previous communications, the endo-abdominal fascia tends to fade out in a very thin, tenuous layer of fibers at the lower end of the canal, but the further one goes from Poupart's ligament, the stronger the structure is. It lies rather loose in the abdomen and may be pulled down and approximated to Poupart's ligament without great tension, and in the direct hernia it makes a definite covering of the sac. The first stage, therefore, in the closure of any direct hernia should be an inversion suture placed directly in the floor of the canal (Fig. 7). This inversion suture should be of chromic catgut or some other durable material and should be placed in an oval manner so as to invaginate the dome-shaped bulging into the abdomen until the floor of the canal can be palpated as a flat structure and until it no longer bulges when the patient strains. Sometimes a single suture of this type is necessary (Fig. 8) and sometimes two may be put in if the hernia is an unusually large one (Fig. 9). In the complicated type in which a rupture of fascia has occurred and a diverticulum appeared, this diverticulum need not be resected but may be simply inverted and its neck, which is generally quite small, closed with a stitch or two (Fig. 10).

If this inversion of the floor of the canal has been made, it will practically always be apparent that just above the suture line, the transversalis fascia is very much stronger than just below and that this portion of the transversalis fascia may then easily be sutured to the shelving edge of Poupart's ligament without undue tension (Fig. 11). The technique must be varied to suit the individual case and I usually sew this into Poupart's ligament with one row of stitches and the external oblique with another row but it is easily possible in many cases to include them both in the same stitches and thus save a few knots which would lie in the inguinal canal. Following this the cord may be laid back in its bed and the roof of the canal made with the left-over fragments of the external oblique aponeurosis.

The use of the rectus sheath. It is at the lower end of the canal at the angle between the rectus and Poupart's ligament that most of our recurrences take place and special care and special precautions are necessary here. A number of methods of making use of the rectus have been described and most of them look better in the illustration than in the actual operation. The easiest, most obvious use of course is to suture the unopened rectus sheath directly to Poupart's ligament, but in my experience this has most invariably been accomplished under such great tension that I have felt it necessary to take the stitches out again. Secondly, the rectus sheath may be opened by a longitudinal incision and some of the fibers of the rectus pulled out and sutured into Poupart's to fill up this critical gap. Here, too, we are encountered with the doubtful possibility of union between fibrous tissue and muscle even though the tension may be less in this case. I generally make use of some sort of a Halstead technique turning down a flap of the rectus sheath, and I believe that this should be done in practically every case where the conjoined tendon is deficient. This method, however, is not as strong as it looks in the beautiful illustrations of Max Brödel. The fibers run longitudinally and the flap tends to shred out and split as it is turned over and I am beginning to count more and more on my sutures lying within the canal than I do on any use of the rectus sheath, although I believe it should be used in all cases.

Fascial transplants should be used in every case in which the structures about the canal appear weak or in which the edges of the opening come together only under considerable tension. These are best taken from the thigh, although the use of preserved fascia has proved good experimentally. It appears to be infiltrated with scar tissue and to remain in place indefinitely. I have had no personal experience with it.

The important point in the use of grafts is in the correct placing of them. I have seen surgeons lay a fascial graft over the canal when the operation was completed. This can be of no possible use. Such a graft could only tend to prevent the growth of a recurrence already established. The proper place to use a graft is at the innermost possible point so as to prevent a hernia getting started. The graft need never be very large, merely enough to completely fill up the inguinal triangle with about a centimeter to spare around the edges. It should first be tucked under Poupart's ligament and sutured in place there. The medial portion is then trimmed to fit, the rectus retracted and the graft again sutured under its edge. The upper portion generally presents difficulties, as the structures to which it must be sewed are rather vague. If a conjoined tendon is present, it is raised and the graft sutured to its under surface by through and through sutures. In other cases it must be attached to the outer surface of transversalis fascia as high up as possible. The cord may be brought through a slit in the graft which is then closed snugly, or it may be left at the outer and upper angle of the wound—never at the pubic end, where most of the recurrences take place.

Castration. In bad cases there is no doubt that castration offers a far better prognosis. As direct hernia is a disease of the aged and as the ones operated upon are usually the extreme types, the surgeon should not hesitate to explain to the patient the benefits thus derived. If any hole has to be left for the passage of the cord it is naturally a weak spot where recurrence is likely.

RESULTS OF OPERATIONS

The accompanying table hardly requires comment. It includes figures from such well known institutions as Johns Hopkins Hospital, the Massachusetts General Hospital and the Presbyterian in New York, as well as famous clinics abroad. Two things stand out. First, that the results are so bad as to constitute a major surgical scandal. Second, the Bassini type of operation is totally unsuited to such cases. Analysis of the table shows that about twice as many direct hernias recur after Bassini operations as after other types. The best results obtained are those in which a fascial type of operation has been employed.

It is quite striking to note in the table that the only series of cases in which low recurrence rates are reported are those in which the follow-up data were gotten by letter.

TABLE I.—RECURRENCE IN DIRECT HERNIA

Author	Date	Per cent recurrence	Cases	Operation
1. Andrews, Billings Hospital	1933	27	48	Various
2. Burrows	1931	32	28	
3. Blake		25		Various
4. Cattell	1931	7.8	51	Fascial repair
5. Druener	1919	21 15	28 143	Bassini repair Hackenbruch
6. Erdman	1923	16.61	313	Various
7. Hoguet*	1923	6.4	269	
8. Lameris	1912	28		Bassini
9. Ledermann*	1932	4.1	72	
10. Lyle	1928	9.5 14	54 71	Fascial repair Catgut repair
11. Neidlich	1921	23	222	Bassini
12. Taylor	1920	18.08	256	
13. Davis*	1916	8	15	

Total operations, 1545.
Average recurrence rate, 20 per cent.
*Follow up by letter.

When one considers that these recurrences are more dangerous by far than the original hernias, it seems high time that the subject was thoroughly reconsidered.

SUMMARY

1. Direct hernia is in most cases a harmless condition carrying very slight risk of strangulation, pain, increase in size, or interference with the intestinal tract.

2. Most cases may be diagnosed before operation if proper care is taken in the examination. The few dangerous ones are usually mistaken for oblique hernias which should be operated.

3. The results of surgery are appallingly bad. Operation is indicated only in the group in which a diverticulum of the dome-shaped sac is present, and this group is generally diagnosed before operation as the oblique type.

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ANALYSIS OF 100 COMPLICATED CASES OF ACUTE APPENDICITIS

Primary Cæcostomy or Enterostomy as a Life-Saving Procedure

EDWARD RAYMOND EASTON, M.D., New York

AND

WILLIAM JAMES WATSON, M.D., New Britain, Connecticut

VITAL statistics for 1929 show deaths from appendicitis as 15.2 per 100,000 population as compared with 11.8 in 1919 and 9.7 in 1900. This large and steadily increasing mortality has aroused widespread attention and called forth many valuable contributions to the literature. It is generally agreed that the high death rate is due to three major causes:

1. Indiscriminate use of purgatives by the lay public.
2. Delayed operation.
3. Imperfections in operative technique.

The importance of public health education as to the danger of taking laxatives for every "stomach ache" has been stressed repeatedly; yet the practice continues among the less educated masses. In a series of 4,270 cases collected by Boland from 8 hospitals in Atlanta, nearly every colored patient had taken large doses of some strong purgative such as castor oil or epsom salts. Fourteen per cent of the colored patients died, as against 3.6 per cent of the whites.

Equal in importance is the length of time between onset of symptoms and operation. The delay usually occurs outside the hospital, and is due to lack of medical advice or to obscurity of diagnosis. This factor, like the first, is seen to operate more extensively among the poor and uneducated, for whom medical aid is less readily available. In Boland's series, the average length of time before reaching the hospital was 104 hours for colored patients and 51 hours for whites. Boland believes this long delay, coupled with the use of pre-operative cathartics, is accountable for the great mortality from appendicitis among negroes in the South.[1]

The series of 100 cases under consideration here is taken from the records of Knickerbocker Hospital for a period of 2½ years from January, 1931, to July, 1933. During that time 441 cases of appendicitis of all types were treated, with 12 deaths, a percentage of 2.7. This compares with Finney's finding of 2.3 per cent mortality in 3,913 cases of all types and Boland's 4.4 per cent in a series which included acute cases only.

[1]Boland points out, however, that while the mortality is high among negroes who *have* appendicitis, the incidence of the disease is much lower in the colored race than in the white.

For the purpose of this study, 100 of the most seriously complicated cases were chosen. A complicated case, as here considered, is one with a pathological picture of (1) gangrene, (2) abscess, (3) perforation, or (4) acute diffuse peritonitis. In rating the gravity of these various conditions, our observation has led us to place them in this ascending order, with acute diffuse peritonitis ranking as the most serious. If a case presented more than one of these conditions, it has been classified under the most severe; for example, gangrene with perforation is placed under the head of "perforation." The number of cases and deaths in each group were as follows:

Complication	Cases	Deaths	Cause of death
Gangrene	31	2	1 Pneumonia 1 Pneumonia and sepsis
Abscess	20	1	Peritonitis
Perforation	26	4	3 Pneumonia 1 Suicide
Acute diffuse peritonitis	23	5	Acute diffuse peritonitis
Total	100	12	

In 42 per cent of these complicated cases there is a positive statement of pre-operative catharsis. Six of the 12 who died had taken a purgative of some kind.

Among the fatal cases the length of time from onset to operation averaged 2.7 days. This is only fractionally longer than for the cases that recovered.

While the figures in this series do not in themselves confirm those of Boland and other observers, they seem to show that the two factors of catharsis and delay are of paramount importance in accounting for the high mortality from appendicitis.

In this paper, however, chief consideration is given to the factor of operative technique. It is desired to call attention to the value of enterostomy as a life-saving measure in a limited number of cases of extreme severity, and also to call attention to the fact that this procedure is more likely to be successful if done at the time of the primary operation rather than later on as a secondary procedure.

IMPORTANCE OF OPERATIVE TECHNIQUE

Appendectomy has now become so common an operation as to be considered within the capacity of the average surgeon. The apparent simplicity of an appendicitis operation, however, is often misleading. It must be borne in mind that, while the removal of the appendix itself is not usually a difficult problem, the proper treatment of its associated complications, either at the time of, or subsequent to, the operation requires the exercise of a high degree of surgical judgment if a fatal issue is to be averted. Even in competent hands, the mortality is needlessly high. Thus Fishbein, commenting on the 25,000 deaths last year from appendicitis, states that four-fifths of that number could have been prevented.

The force of this generalization was brought home to the writers by the striking recovery of a patient whose condition had been considered desperate.

CASE No. 1541. M. C., female, aged 38, was admitted to Knickerbocker Hospital May 18, 1933. Patient had suffered a dull, aching pain in the right lower quadrant for 3 weeks. The day before admission the pain suddenly became acute and vomiting occurred. Physical examination elicited pain, tenderness, and rebound tenderness over the abdomen, more marked over McBurney's point. An indefinite mass was felt in the right iliac fossa. Temperature was 102 degrees, pulse 118. Leucocytes numbered 18,000, polymorphonuclears, 86 per cent.

The case was diagnosed as appendiceal abscess and operation was performed under ether anæsthesia.

When the peritoneal cavity was opened through a right rectus incision, cloudy fluid with colon bacillus odor gushed forth. A plastic exudate covered the intestines below the cæcum, where there was an abscess containing several ounces of thick pus. The peritoneum throughout appeared to be involved in a process of diffuse peritonitis. The appendix had evidently disintegrated entirely; no trace of it was seen, but at its site there was a thickened, angry cæcal wall and distended lower ileum. The uterus was large and soft; the adnexa were not seen. Adhesions over the back of the uterus prevented palpation behind it.

The abscess cavity was opened and drained with suction. Drains were placed in the abscess, pelvis and right lumbar gutter, and the incision was closed in layers, with drains in lower angle.

Before the incision was closed, the cæcum was brought up through a stab wound in the right lower quadrant and a pursestring suture placed in the exposed area. Within the suture an incision was made and a No. 20 French catheter inserted, after which the pursestring was tied. By a second pursestring suture, the cæcostomy was inverted and the cæcum pushed back into the abdomen.

The postoperative condition of the patient was good, and she had no distention at any time. The cæcostomy began to drain freely on the second day. The cæcostomy tube was removed on the third day. Seven days after operation the drains were shortened. There was still a fairly profuse drainage of yellow serous fluid and a slight purulent drainage from the cæcostomy wound. At this time there was no fæcal discharge. The condition of patient continued good. Twelve days after operation drains were entirely removed and the wound was irrigated with Dakin's solution; the cæcostomy wound was clean and the blood count excellent.

Patient was discharged in good condition June 7, 20 days after admission. Postoperative diagnosis was acute appendicitis, abscess of appendix, acute diffuse peritonitis. One week after discharge both wounds had entirely healed.

Owing to the character and extent of the peritonitis disclosed, a fatal termination might have been momentarily expected. It is believed that the primary cæcostomy prevented the onset of paralytic ileus and accounted in large part, if not wholly, for the fortunate outcome.

A review of the 100 similarly complicated cases was then undertaken to determine, if possible, the factor or factors that led to success or failure in apparently hopeless conditions. A brief résumé follows:

With one or two exceptions, either the McBurney or right rectus incision was used, depending chiefly on the preference of the operating surgeon. In instances in which there is no doubt as to the diagnosis of appendicitis, the McBurney incision is preferred by the writers as allowing direct access to the affected area and a minimum handling of the intestines.

One to four drains were inserted, as the condition required. Routine postoperative treatment was given, in whole or part—morphine, codeine, clyses, Fowler's position, retention enemas, pituitrin, Levine tube, Murphy or Harris drip.

The original operation was supplemented in 4 cases by a primary cæcostomy only. There were 2 cases in which multiple collateral operations were done simultaneously: one, a primary cæcostomy and ileostomy; the other, a secondary cæcostomy and jejunostomy, 7 days after the appendectomy. There were three primary appendicostomies. One patient, who had a primary ileostomy, was discharged with an intestinal fistula and returned later for secondary closure. In 3 cases there were secondary ileostomies, performed respectively 4, 5 and 17 days after operation. In five other cases spontaneous fæcal fistulæ developed at some time subsequent to operation. Details of these cases are given in the following Table I.

As will be seen, all of the 18 patients having the supplementary operation of fæcal fistula made a good recovery, with a single exception. This patient (Case No. 502) had taken cathartics twice on the day before admission. There had apparently been a lapse of 4 days between onset of symptoms and operation, but this could not definitely be determined as the patient had been under the influence of alcohol for 2 days. Due to extreme distention following the original operation, ileostomy was done 5 days later under local

TABLE I.—ENTEROSTOMY AND FÆCAL FISTULA CASES

Case No. Sex Age	Onset to operation	Cathartic	Pathology	Enterostomy or fistula	Result
502 M 45	4 days	Epsom salts	Acute suppurative, gangrenous appendix	Secondary ileostomy 5 days postop. Local anæsthesia	Died of lobar pneumonia 5 days later
1532 M 74	1 day	No history	Irreducible left inguinal hernia. Gangrene, perforation, diffuse peritonitis	Primary cæcostomy	Closed on 20th day
1960 F 30	36 hrs.	No history	Gangrene with diffuse peritonitis	Secondary ileostomy, 17 days after operation	Closed in 10 days
2062 M 19	2 days	No catharsis	Gangrenous appendix with large fæcolith	Fistula on 5th day	Closed on 13th day
58 M 19	3 days	Citrate of magnesia	Gangrenous	Fistula on 23d day postop., after secondary operation for postoperative hæmorrhage	Fistula closed in 13 days
1138 M 20	3 days	Castor oil	Gangrenous and free pus with B. coli communis, diffuse peritonitis	Primary cæcostomy and ileostomy (simultaneous)	Both closed on 8th day
1184 F 62	2 days	Castor oil	Gangrenous and perforated	Primary appendicostomy	Closed 38th day, stormy convalescence
1426 M 32	2 days	Pills and citrate of magnesia	Gangrene and acute diffuse peritonitis	Primary cæcostomy	Closed on 10th day, smooth convalescence
1499 M 25	2 weeks	Several unnamed cathartics	Large abscess right iliac fossa. Part of gangrenous appendix found	Fæcal fistula on 20th day	Closed on 34th day
1518 M 30	4 days	Cathartic taken, unspecified	Gangrene, acute diffuse peritonitis	Enterostomy (probably ileostomy), primary	Secondary closure 3 wks. after operation. Discharged with fistula. Successful closure and inversion of fistula on later admission
1719 M 30	2½ days	No cathartics	Gangrene, perforation, ruptured abscess	Primary cæcostomy	Closed 12th day
2070 M 38	3 days	Castor oil and other cathartics	Gangrene, perforation, abscess	Primary appendicostomy	Closed 14th day
2333 F 14	2 days	No cathartics	Gangrene, perforation, abscess	Secondary enterostomy on 4th day (ileostomy?)	Closed 20 days after secondary operation
2509 M 33	3 days, pain since fall on abdomen	Cathartic taken, unspecified	Gangrene, perforation, abscess	Fæcal fistula on 11th day, with immediate improvement	Secondary closure on readmission 4 months after discharge
2802 M 31	2 days	Pluto water	Gangrene, perforation, abscess	Fæcal fistula 10th day	Closed on 24th day
401 F 58	2 weeks, worse last two days	Epsom salts	Gangrene, perforation, abscess	Primary appendicostomy	Closed on 8th day
1766 M 8	33 hrs.	Cathartic taken, unspecified	Gangrene, acute diffuse peritonitis, cæcum markedly distended, lusterless, covered with plastic exudate. Blood vessels engorged	Secondary cæcostomy and jejunostomy 1 week postoperative	Jejunostomy closed after Potter treatment in 5 days. Cæcostomy had to be closed secondarily 5 wks. later
1541 F 38*	3 weeks	No catharsis	Gangrene, abscess, generalized peritonitis	Primary cæcostomy	Closed 20th day

*This case fully described in text

anæsthesia. The patient was doubtless suffering from lobar pneumonia when the secondary operation was done, although that condition was not diagnosed until the day of his death, 5 days afterward and 11 days after admission. The possibility of recovery in this case, had the enterostomy been done primarily, must be considered.

The only jejunostomy in this series was done a week after operation, in conjunction with a cæcostomy, which may account for the favorable

outcome. Blake advocates the double operation where indicated, if the stomata are at a distance from each other, and Quain and Waldschmidt sometimes find it necessary to do a multiple collateral operation with three, or even four, artificial openings.

The 6 patients in the entire series who died from acute diffuse peritonitis might likewise have been saved by a primary enterostomy or cæcostomy, since paralytic ileus resulting from peritonitis is usually the direct cause of death in such instances. However, in fulminating cases, this procedure must be supplemented by early, small, and repeated transfusions to overcome the infection. This combined treatment has been seen to produce dramatic effects in certain apparently desperate conditions.

Blake says it is the consensus, if enterostomy is to be done at all, that it should be at the time of the primary operation. He believes it is almost uniformly unsuccessful if deferred, but if enterostomy is done early there is no question as to its value, many lives having been saved by such a procedure.

The advantages of primary enterostomy or cæcostomy are: (1) that it forestalls the onset of postoperative paralytic ileus, a common complication after all abdominal operations; (2) that it prevents obstruction from adhesions by keeping the intestine in normal motion and allowing prompt escape of gas and fluid; (3) that the wound heals almost as promptly, if the proper technique is used, as the appendiceal wound, and causes no additional strain upon the patient.

FREQUENCY OF POSTOPERATIVE ILEUS

According to Delprat and Weeks, the later occurrence of ileus can be predicted at the time of operation. If abdominal infections have been stirred up or if there has been undue handling of abdominal organs or intestines, one may confidently expect ("and," they add, "is seldom disappointed") paralysis of the intestine which lasts a varying period of time. Onset of symptoms is within 12 to 24 hours. Dynamic ileus may develop at any time after operation. A combination of both forms is not uncommon.

Ochsner, Gage, and Garside give a similar opinion. "One must agree with Deaver," say these authors, "that severe acute appendicitis always causes a certain degree of peritonitis." Closely associated with (and usually a result of) peritonitis, is ileus. In all cases of peritonitis, especially the diffuse variety, the presence of a greater or less degree of paralytic ileus may be assumed.

It is often found on admission, here as in other hospitals, that the infection is no longer confined to the region of the appendix. Thus, of 193 consecutive cases admitted to the Charity Hospital in New Orleans during a period of 22 months, 29.5 per cent presented localized abscesses, 11.9 per cent diffuse peritonitis, and 37.3 per cent required drainage.

According to a compilation, made by these authors, of 6,337 acute cases from nine different sources, 55 per cent of the mortality was due to peritonitis.

Death from peritonitis is due to toxæmia, the toxins being absorbed either from the peritoneal cavity or the paralytic, atonic bowel. By eliminating the toxicity of the bowel through enterostomy, it is possible to compute the percentage of mortality that may be expected from peritonitis alone.

TREATMENT

Ochsner holds that the treatment of acute ileus is purely surgical and is best carried out by establishing an enterostomy or a colostomy. Early diagnosis is essential in order that the proper therapy can be instituted before a profound toxæmia supervenes.

The introduction of an enterostomy tube into dilated, atonic gut may be of little value since it drains only a small portion of the intestine in the immediate vicinity. If, however, it is introduced before the dilatation and atony occur, it is possible to drain the whole intestinal tract.

Moynihan believes that, in the great majority of cases of ileus, the surgeon is called upon too late. "It is not too much to say that in a consecutive series of 20 cases of average intensity . . . in at least 15 the operation has been too long deferred." He advocates two procedures only in the treatment of postoperative ileus: (1) separation of adhesions (when the condition is mechanical) and (2) enterostomy; he uses Coffey's method, a modified Witzel, with the advantage of not producing so great a narrowing of the lumen.

Quain and Waldschmidt report a series of 1000 cases of acute appendicitis in which enterostomy was performed primarily in 31 cases and secondarily in 38. With a few exceptions, the sinuses closed spontaneously. As to the indications for a primary operation, they say, "No rule can be formulated, as each case becomes a law unto itself, but it should be remembered that a properly made temporary opening into the intestines does not injure any of these patients, and that it is the only salvation for many. We have never regretted performing a primary enterostomy; we have often regretted its postponement."

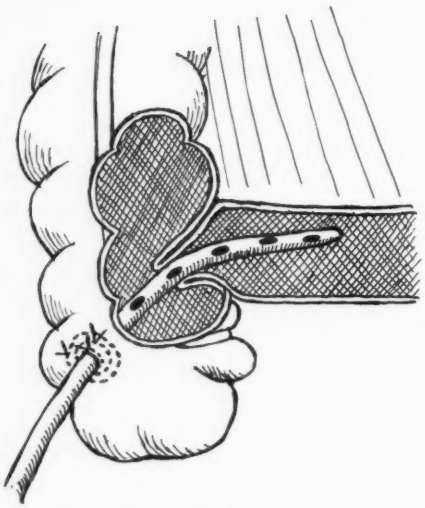

Fig. 1. Cæcostomy with ileum drainage.

Wilkie states that cæcostomy is unquestionably indicated if, at operation, a grossly distended cæcum is found. The comfort this gives, with the ready supply of fluid and absence of violent distention, makes it a valuable addition to an appendix operation in selected cases.

The cases selected for cæcostomy or enterostomy in the present series were those which, when the abdomen was opened, revealed a dull, lusterless gut, distended with gaseous and liquid material, and with plastic adhesions between the distended coils which might be expected to develop into obstructive bands and bring about dynamic ileus.

CÆCOSTOMY

The procedure recommended is as follows:

A No. 20 French catheter, in which several additional drain holes have been made, is stretched and grooved with a scalpel to form a ring about 8 inches from its rounded tip. A stab wound is made lateral to the operative wound just below or mesial to the anterior superior spine, parallel to Poupart's ligament and about one inch above it. The lateral wall of the cæcum is drawn through this opening in the abdominal wall. A pursestring suture of No. 0 chromic or Pagenstecher is placed in the wall of the cæcum. A small puncture wound is then made in the center of this pursestring area. The catheter is passed through the puncture wound in the cæcum and carefully insinuated through the ileocæcal valve (Fig. 1). The pursestring is drawn taut and tied securely at the grooved ring. This area is then inverted with one or two additional pursestrings of No. 0 chromic. The catheter thus placed passes into the lower ileum 4 to 6 inches. The portion of cæcum containing the catheter is pushed back into the peritoneal cavity and caught with a catgut suture at each end of the peritoneal incision so as to hold it firmly to the abdominal wall. A silkworm suture is then passed through both edges of the skin of the stab wound and the catheter to hold the catheter in place. The drainage and closure of the appendectomy wound are then concluded in the usual manner.

This technique is the only practicable one for a cæcostomy. It is recommended entirely on account of the short period of its subsequent closure, as described in Case No. 1541, previously quoted. In this case drainage of fæcal matter had ceased in less than a week, and within 3 weeks the cæcostomy wound had closed entirely. This prompt closure has proved to be the rule in other cases similarly treated.

In the case of a jejunostomy or ileostomy, Wangensteen's technique appears to be the most satisfactory. After any existing distention is "milked" or aspirated out, a No. 14 (French) urethral catheter is laid onto the collapsed bowel and a running stitch of No. 000 chromic catgut enfolds the bowel about it over a length of 1½ inches. A tiny puncture is made and the catheter introduced into the lumen; the fixation stitch is placed and the peritoneal tunnel continued for another 1½ inches. The suture is then completed. This is, in fact, a modified form of the Witzel method. Wangensteen states that a No. 14 catheter will drain the bowel "as well as a garden hose," which is no doubt correct.

Appendicostomy appears to be a very illogical procedure if early healing is expected, since it goes through a portion of the bowel more likely than any other to have been affected by the associated peritonitis. It is preferable to choose a part of the cæcum above, anterior and lateral to the base of the appendix, where the bowel is relatively healthy. This allows the necessary inversion and promotes early healing after the tube is removed.

Whether ileostomy or cæcostomy should be used must be decided according to the local pathology present. In cases of diffuse peritonitis, the ileostomy is probably more desirable, and undoubtedly, where there is extensive dilatation and atony, multiple enterostomies, including jejunostomy, are indicated. The enterostomy should be performed in a free and unkinked portion of the ileum, at least a foot above the ileocæcal

junction. If there is a large localized abscess at this junction, a lateral cæcostomy with ileum drainage will, it is believed, bring about very satisfactory results.

It is not intended to recommend herein so radical a procedure as enterostomy or cæcostomy in every case of diffuse peritonitis or large abscess. Each case, as Quain and Waldschmidt have observed, requires individual consideration. If, however, their further statement, that *they have never regretted performing a primary enterostomy and have often regretted not having done so*, is to receive due weight, it is likely that this operation will be done more frequently in the future than in the past. In a total of 69 enterostomies, 31 of which were primary and 38 secondary, these surgeons found it necessary to do a secondary closure of the fistula in but 10 cases.

SUMMARY

One hundred complicated cases of acute appendicitis, selected for their severity and grave prognosis, have been analyzed. In only one of the 18 cases in which an enterostomy or cæcostomy was done, or in which a fæcal fistula developed spontaneously, did a fatality ensue.

The best results were secured when the collateral operation was done primarily. In these cases, it proved a life-saving measure. In certain doubtful cases, also, enterostomy (or cæcostomy) as a prophylactic procedure against the development of paralytic ileus seems more than justified. At all events, it can scarcely be considered to increase the gravity of appendectomy in the presence of a spreading peritonitis.

The writers wish to express their appreciation to the Surgical Director, Dr. Ellsworth Eliot, and the Surgical Staff, of Knickerbocker Hospital for permission to publish this series of cases and for the many helpful suggestions made by them in the preparation of this paper.

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TOTAL REMOVAL OF LEFT LUNG FOR BRONCHIECTASIS[1]

CAMERON HAIGHT, M.D., ANN ARBOR, MICHIGAN
From the Department of Surgery, University of Michigan

IN occasional cases of non-tuberculous pulmonary suppuration or neoplasm, complete removal of the affected lung offers the most certain and, at times, the only means of cure. The feasibility of resection of an entire lung has been demonstrated experimentally by many investigators, several of whom achieved notable success. The clinical application of this procedure, however, has been unsuccessful except in the single instance of Nissen, who, in 1931, resected the entire left lung for bronchiectasis.

In the patient who is the subject of this article, the delayed removal of an aspirated foreign body resulted in a widespread pneumonitis and bronchiectasis of the left lung. Soon after the removal of the foreign body, the patient developed a spontaneous tension pneumothorax and an acute empyema which required immediate airtight drainage of the pleural cavity. As conservative measures and, later, an extensive thoracoplasty were unsuccessful in relieving the symptoms of the severe residual bronchiectasis, complete removal of the affected lung was finally undertaken. The detailed history of the case follows:

CASE REPORT

Vivian L., aged 13 years. The patient had been in good health prior to the onset of the present illness on January 15, 1932, at which time two teeth were extracted under gas anæsthesia. During the extraction the mouth was held open by a mechanical apparatus. On regaining consciousness following the anæsthesia, the patient complained of a tickling sensation in the throat, followed by a severe attack of coughing, nausea, and vomiting. The symptoms of a severe pulmonary suppuration soon developed. Roentgenograms taken 3 weeks after the onset of the illness showed an infiltration of the greater portion of the left lung, a foreign body in the left main bronchus, and a pleural reaction as of effusion. Although thoracentesis was performed on three occasions, no pleural fluid was obtained.

On February 17, 1932, 33 days after the onset of the illness, the patient was admitted to the University Hospital. She was acutely ill, coughing severely, and expectorating large amounts of foul sputum. Examination of the chest revealed immobility of the left side, flatness, absent breath sounds, and tactile fremitus except at the left apex. The physical findings were those of an occlusion of the left primary bronchus with a drowned lung. There were no abnormal physical findings in the contralateral lung. The rectal temperature was 103.6 degrees F.; pulse, 140; and respirations, 60. The leucocyte count was 21,350. On roentgenoscopic examination by Dr. Carleton B. Peirce, the left thorax appeared to be almost uniformly obscured except for several patchy air-containing areas in the upper lobe at the level of the hilum. Roentgenographic examination made through a Potter-Bucky diaphragm revealed a shadow of soft tissue density situated in the region of the left main bronchus. The roentgen diagnosis was a foreign body in the left main bronchus with resultant pulmonary suppuration and pleural effusion.

A bronchoscopic examination was performed by Dr. A. C. Furstenberg on the day of admission. A foreign body surrounded by granulation tissue was observed in the left primary bronchus. Immediately following its removal an enormous quantity of very foul, thick, yellow pus was liberated. The amount was so great that it could not be aspirated through a suction tube and much of the pus flowed into the right primary bronchus, greatly embarrassing the child's respirations. For several hours following removal of the foreign body, the patient was exceedingly cyanotic and death seemed imminent. On inspection of the foreign body, it proved to be a piece of black rubber (1.7 centimeters by 1.2 centimeters by 0.6 centimeter), which had become dislodged from the mouth gag during the extraction of teeth.

The patient's condition remained critical. Despite postural drainages every 2 hours, she continued to expectorate large amounts of foul smelling pus in the intervals between drainages. There was a constant temperature elevation of from 101 degrees to 103.6 degrees F. by rectum. Roentgenograms taken 6 days after the bronchoscopy showed a pneumonitis of the central portion of the right lung and only slight clearing of the infiltration in the left upper lobe; the lower half of the left thorax presented a uniform opacity. On the following day, thoracentesis was productive of 5 cubic centimeters of thin, straw colored, sterile fluid. It was planned to treat the pulmonary suppuration by bronchoscopic aspirations, and on February 29, this was begun.

On March 2, 1932, the patient suddenly became dyspnœic and cyanotic. A diagnosis of perforation of the left lung with a spontaneous tension pneumothorax was verified by thoracocentesis, which revealed the presence of a large amount of foul smelling air under positive pressure. Air and considerable thick, foul, yellow pus containing spirochætæ, fusiform bacilli, and various pyogenic organisms were aspirated. Intercostal airtight drainage of the pleural cavity was immediately instituted and constant suction was applied to maintain expansion of the lung. It was necessary to keep the patient in an oxygen tent for 4 days, during which time there was gradual clinical improvement, although roentgenograms demonstrated a pneumonic infiltration in the lower half of the right lung. Two blood transfusions were given and an abscess which developed beneath the extracostal muscles at the site of the last thoracocentesis was drained.

The pneumonic process in the right lung cleared gradually and the empyema cavity decreased rapidly in size. The pulse, temperature, and respirations remained elevated and the daily amount of sputum varied between 40 and 192 grams. On March 29, 1932, a temporary surgical interruption of the left phrenic nerve was produced. The patient continued to cough and expectorate foul sputum at frequent intervals and at times the cough was so severe that it provoked vomiting.

A series of four bronchoscopic aspirations was begun on April 16 and postural drainages were given at frequent intervals during the day and night. At each bronchoscopy, copious amounts of purulent secretions were aspirated,

[1]Presented before the Detroit Academy of Surgery, April 13, 1933.

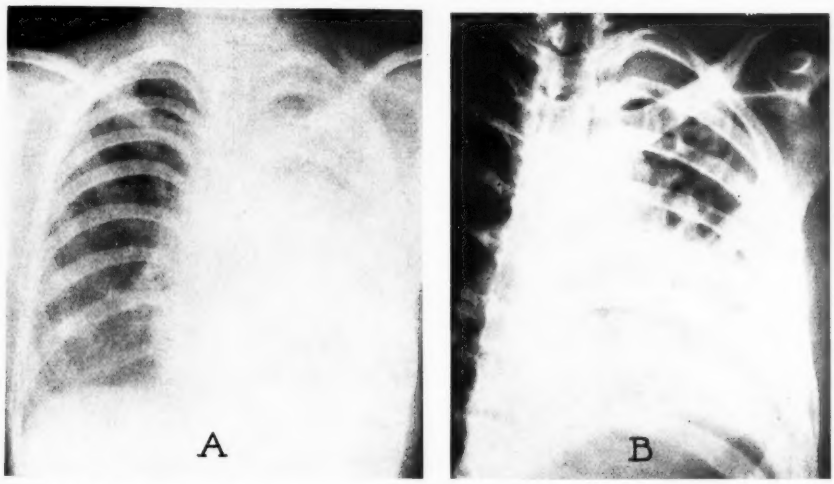

Fig. 1. A, July 5, 1932. Roentgenogram, routine technique, prior to thoracoplasty. The gross infiltration of the left lung is partially obscured by pleural thickening, resulting from the healed empyema. The pneumonitis that was present in the right lung several months earlier has now cleared. B, Same date. Roentgenogram, Potter-Bucky technique, demonstrates multiple small cavities throughout the left upper and lower lobes.

especially from the left lower lobe bronchus. The lumen of the left lower lobe bronchus was slightly narrowed by granulation tissue, but there was no apparent stenosis of the left main bronchus. Lipiodol was injected bronchoscopically but the resultant filling was unsatisfactory. A third blood transfusion was given. As spirochætæ and fusiform bacilli were demonstrated in the sputum, a course of six injections of neoarsphenamine at weekly intervals was started on June 14, but no beneficial effect was noted. The empyema cavity had become obliterated and the small remaining sinus in the thoracic wall closed within several weeks.

Although there had been some improvement from the conservative management of the pulmonary suppuration, the patient's general condition became stationary. The temperature showed a slight daily elevation, the pulse rate varied from 90 to 140, and the respirations from 20 to 30. There was an average daily expectoration of 190 grams of foul, purulent sputum. Physical and roentgen examination (Fig. 1) showed extensive disease of the entire left lung. By the use of the Potter-Bucky diaphragm numerous small abscesses, presumably bronchiectatic, were seen in the left upper and lower lobes, although visualization of the latter was greatly obscured by pleural thickening. The pneumonitis in the right lung appeared to have cleared completely. It was felt that an extensive staged thoracoplasty offered a chance of collapsing the numerous small cavities. As a thoracoplasty involved less risk than a pneumonectomy, it was decided to postpone the latter and to use it only in the event that the thoracoplasty should be ineffective.

As a preliminary measure to the thoracoplasty, a parasternal division of the first to fourth costal cartilages was done on July 20, 1932, so that the anterior rib stumps remaining after the thoracoplasty would be free to swing mesially, thereby increasing the thoracoplastic collapse. At about 17 day intervals, moderate lengths, 110.5 centimeters, of the first to eleventh ribs were resected posterolaterally in four stages. The thoracoplasty was completed on September 29, 1932. The patient withstood the many stages remarkably well, although the pulse rate became quite rapid during each procedure. As a supportive measure, two blood transfusions were given during this period.

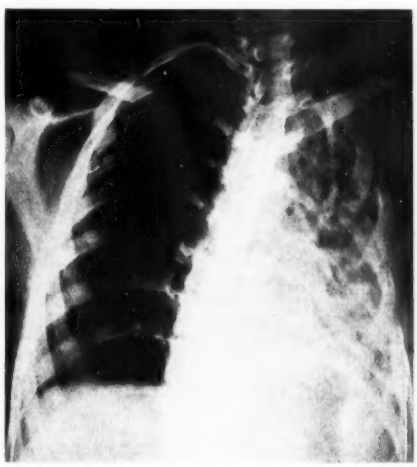

Fig. 2. October 15, 1932. Roentgenogram, Potter-Bucky technique, after completion of a moderately extensive posterolateral thoracoplasty and 3 weeks prior to pneumonectomy. The collapse of the thoracic wall is unsatisfactory, and the multiple cavities in the left lung persist.

Fig. 3. Technique used in the ligation of the left upper and lower lobes during the second stage of the pneumonectomy. Both lobes have been completely separated and the interlobar fissure has been opened. The pedicle of each lobe has been ligated with heavy, doubled braided silk and a rubber tube. The pneumonectomy was performed through the upper thoracoplasty incision (inset). The black dot in the lower thoracoplasty incision indicates the location of the intercostal tube for airtight drainage of the pleural cavity. Continuous drainage of the pleural cavity, instituted at the first stage of the pneumonectomy, was maintained until the eleventh day following the second stage.

The result of the thoracoplasty was not satisfactory. The general condition was somewhat improved but the patient continued to cough severely, raising about 140 grams of foul, purulent sputum daily. On October 15, 1932, roentgenograms (Fig. 2) taken with the Potter-Bucky diaphragm after completion of the thoracoplasty demonstrated multiple residual areas of decreased density throughout the entire left lung field which showed gross infiltration. The appearance was one of multiple small abscesses. A right dorsal and lumbar scoliosis which had developed prior to the thoracoplasty was only slightly increased by the operation.

As several attempts to introduce lipiodol by the supraglottic route had been unsuccessful, it was endeavored to secure a satisfactory filling by means of an intratracheal catheter introduced with the aid of a laryngoscope. With the patient reclining on her left side, lipiodol was injected through the catheter and its progress was observed roentgenoscopically. The lipiodol failed to flow into the left main bronchus; instead, it flowed upward into the right lower lobe bronhus. From this observation, a stenosis of the left main bronchus was suspected; this was confirmed by bronchoscopic examination on October 31, 1932. At a distance of 2 centimeters below the carina, the left main bronchus was greatly narrowed. The stenosis admitted a No. 14 F. bougie but there was a definite resistance felt on withdrawing the bougie. Due to the presence of a partial stenosis, it was believed that further improvement of the suppurative bronchiectasis could not be expected. Accordingly a total left pneumonectomy was decided upon, as it was believed that a complete removal of the diseased lung offered a more certain means of cure than would either a wide cautery drainage or an anterolateral thoracoplasty. It was feared, however, that the pleural adhesions resulting from the empyema and the thoracoplasty, might prove inseparable. The vital capacity was recorded before the

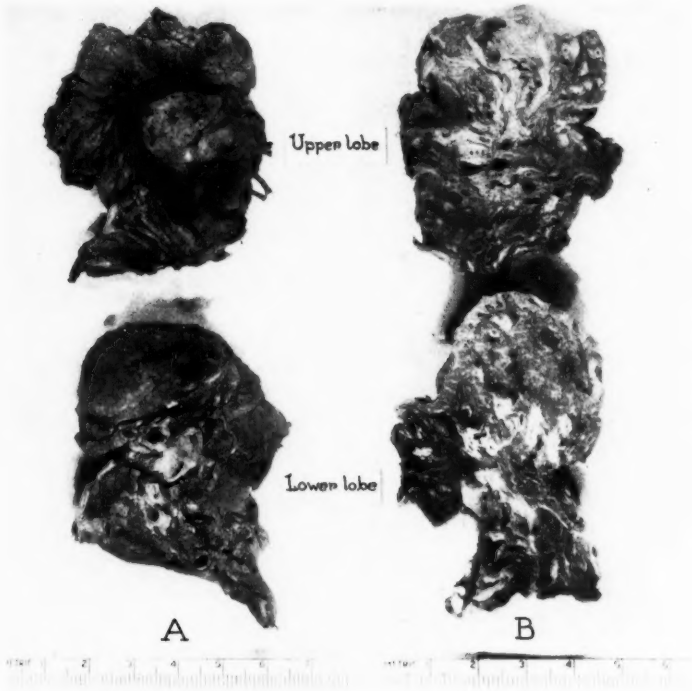

Fig. 4. A, Mediastinal surface of the greatly shrunken and necrotic upper and lower lobes which separated spontaneously 16 and 17 days, respectively, after ligation at the second stage of the pneumonectomy. The upper lobe ligatures are still attached to the lobar pedicle. B, Cross section of both lobes reveals small bronchiectatic cavities, considerable fibrosis, and lack of normal, air-containing tissue.

pneumonectomy but unfortunately this observation is missing from the patient's chart. However, I am under the impression that it was 1,250 cubic centimeters, 49 per cent normal (Stewart).

First stage pneumonectomy, November 8, 1932. Nitrous oxide and oxygen anæsthesia was used. During the few hours immediately before operation, several postural drainages were given at frequent intervals, so as to empty the bronchiectatic pockets as completely as possible. The patient was placed on her right side, on an inclined table with the head lowered about 25 degrees. The upper stage posterolateral thoracoplasty incision was reopened and the incision was extended inferiorly and anteriorly. The regenerated fourth, fifth, and sixth ribs were resected and the anterior stumps of these ribs were removed to the midaxillary line. When the parietal pleura was incised, the lung was found to be grossly adherent to the thoracic wall. The pleural adhesions were readily separable by blunt dissection. The lower lobe was congested, considerably decreased in size, and firmer in consistency than normal. It was freed from the thoracic wall, the diaphragm, and partially from the upper lobe. No attempt was made to divide the pulmonary ligament of the lower lobe or to separate the upper lobe, as the pulse rate, which was 138 at the beginning of the operation, had increased to 168. A fenestrated tube for airtight drainage of the pleural cavity was introduced through an intercostal stab wound at the level of the costophrenic angle, and the main incision was closed.

The immediate postoperative recovery was satisfactory and on the following day a transfusion of 400 cubic centimeters of blood was given as the hæmoglobin had decreased from 76 per cent to 54 per cent (Sahli.) The highest postoperative temperature was 100.4 degrees on the first postoperative day and on the succeeding days there was about 1 degree of elevation.

Second stage pneumonectomy, November 14, 1932. The second stage of the pneumonectomy was performed 6 days after the first stage. Postural drainages were again employed before the operation. The position on the operating table was the same as that employed at the first stage. Nitrous oxide anæsthesia was again used. The incision was reopened, the intercostal drainage tube removed, the lower lobe was freed from its newly formed adhesions, and the pulmonary ligament was divided. The lower and upper lobes were completely separated at the interlobar fissure. As the patient's condition had remained satisfactory, separation of the upper lobe was then begun. The adhesions about the upper lobe were more dense than were those about the lower lobe, but with some difficulty, they were completely separated. It was necessary to free the mediastinal surface of the lobe above its hilum before separation of the

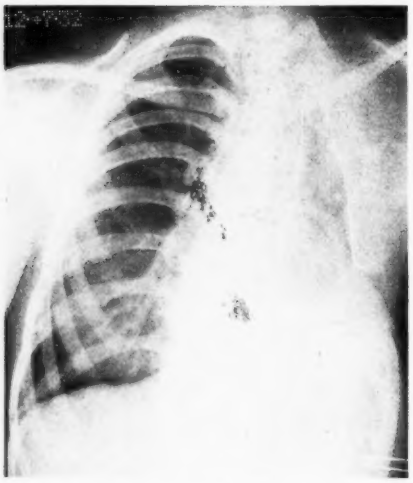

Fig. 5. December 7, 1932. Roentgenogram 23 days after total removal of the left lung. The residual pleural defect is indicated with a penciled line.

very adherent apex could be carried out. Both lobes were thus completely freed and a satisfactory pedicle to each lobe was developed. As the mediastinum had become somewhat thickened by the preceding empyema, it was necessary to use only mildly positive pressure anæsthesia during and after separation of the lung.

It had been planned to enclose the lung in rubber sheeting (a very thin bathing cap had been procured for the purpose) in order to await further fixation of the mediastinum and formation of a protective inflammatory reaction of the parietal and mediastinal pleuræ before proceeding with ligation of the lobes. This plan was abandoned for the following reasons: The mediastinum was already partially fixed; a small tear had been accidentally made in the lower lobe, exposing the pleural cavity to infection, and most importantly because it was felt that gauze packing was essential to control the considerable oozing from the parietal pleural surfaces. The pedicles of both lobes were ligated separately with an encircling mass ligature of heavy braided silk placed close to the junction of the lobes. An elastic rubber tube ligature was tied around each pedicle, slightly distal to the braided silk, in order to maintain continuous strangulation of the lobes as the tissues receded from the silk ligatures (Fig. 3). An additional braided silk ligature was placed distal to the rubber tube ligature around the lower lobe pedicle (not illustrated). During ligation of the lobes, no cardiocirculatory or respiratory changes were observed. The lobes were not excised but they were allowed to become necrotic and eventually sequestrate when the ligatures cut through the pedicles. Gauze soaked in acriflavine solution was wrapped loosely about both lobes in order to control the oozing, to stabilize the mediastinum, and to prevent the necrotic lung from becoming adherent to the thoracic wall. Two irrigation tubes were inserted through the incision, the airtight intercostal drainage tube was reinserted, and the wound was again tightly closed. The long ends of the ligatures around the lobar pedicles were brought through the wound and they were anchored externally with a clamp. The patient withstood the procedure remarkably well. The systolic blood pressure during the operation remained elevated above 100 millimeters, and although the pulse rate increased from 120 at the beginning of the operation to 172 at its conclusion, there was no shock. The duration of the operation was one hour and five minutes.

Subsequent course. The immediate postoperative convalescence was thoroughly satisfactory. The pulse rate varied between 116 and 140 and the lowest systolic blood pressure (observed at 15 minute intervals) was 106 millimeters. There was no delayed shock or vomiting and the patient took fluids freely by mouth. A very small amount of slightly bloody sputum was raised immediately following the patient's return to her room. Although she was subsequently encouraged to cough at frequent intervals, she could raise no sputum, as the ligatures had completely occluded both lobar bronchi. A blood transfusion was given about 8 hours following the operation, as the preoperative hæmoglobin had been 60 per cent and the red blood cells 3,460,000. The pleural cavity was irrigated twice daily with acriflavine and later with Dakin's solution. The temperature which reached 102 degrees F. on the first day after operation, rapidly subsided during the following 2 days to 99 degrees. A urinary infection developed on the first day after operation but it likewise soon subsided.

On the fourth day the wound was reopened under nitrous oxide anæsthesia and the intrapleural gauze packing was changed. Both lobes were shrunken and dark and were in a state of dry gangrene. As the mediastinum was somewhat mobile, it was stabilized by anchoring the long ends of the rubber tube pedicle ligatures to the rib immediately below the incision. Gauze was again placed loosely about the lung and the wound was packed wide open with acriflavine gauze. A firm dressing was applied. A smear and culture of the secretions within the pleural cavity showed Staphylococcus aureus and Bacillus pyocyaneus. The convalescence continued to be satisfactory. Seven days later the gauze packing around the lung was again changed under gas anæsthesia and the necrotic lung was slightly exteriorized by the packing. The lobes had further decreased in size and at this time, 11 days after operation, no bronchial fistula had yet appeared. On the sixteenth day after operation, the upper lobe was found lying loose in the wound and it was removed. The lower lobe sloughed off on the following day.

The gross examination of the greatly shrunken and necrotic lobes was reported by Dr. L. A. Brewer as follows: The upper lobe measures 6 centimeters by 4.5 centimeters by 3 centimeters, weight 25 grams. There are ligatures about the hilum and bronchus which have contracted to form a fibrotic mass. The lung itself is composed of a necrotic, pale yellowish green tissue which has a fleshy consistency. The cut surface shows small cavities varying in size from 1 to several millimeters. One cavity is 1 centimeter in diameter and an oval bronchiectatic cavity measures 6 millimeters by 4 millimeters by 2 millimeters. The cut surface also reveals the major portion of the lobe to be composed of scar tissue. The lower lobe is composed of the same fleshy, fibrous tissue which is necrotic and contains smaller cavities which are very scant in their distribution (Fig. 4). The microscopic examination was reported by Dr. J. C. Bugher: The upper lobe presents a moist gangrene involving the entire lobe. Multiple bronchiectatic abscesses with heavy scar tissue walls are present. There is a diffuse fibrosis of the lobe and slight anthracosis. The lower lobe presents the same appearance as the upper lobe. The only living cells are polymorphonuclear leucocytes.

Following the spontaneous separation of both lobes, a minute bronchial fistula, several millimeters in diameter

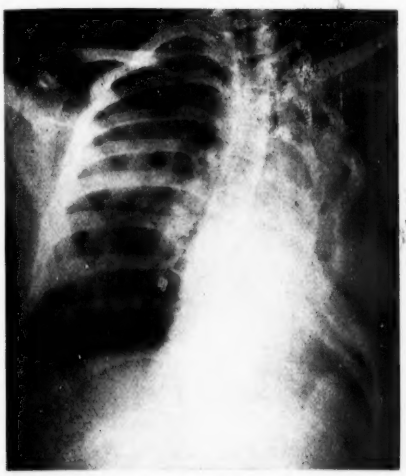

Fig. 6. February 25, 1933. Portable roentgenogram 14½ weeks after the left pneumonectomy and 6 days after the development of an acute pulmonary abscess in the right lung. The pneumonectomy defect has closed except for a small sinus which is not demonstrable by roentgenographic examination.

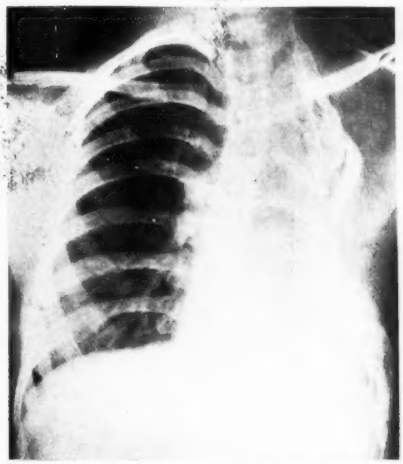

Fig. 7. May 31, 1933. Roentgenogram 6½ months after pneumonectomy and 3½ months after the development of a pulmonary abscess in the right lung. The abscess has cleared under non-surgical therapy. The pneumonectomy defect is completely obliterated.

could be seen in the region of the upper lobe hilum. A fistula from the lower lobe bronchus did not occur. The pleural space was packed daily with gauze, and the pleural defect (Fig. 5) decreased rapidly, being aided by the previous thoracoplasty. Exercises and postural wedge compression (3) were started to correct the rather prominent right dorsal and lumbar scoliosis, which, although present before the pneumonectomy, was increased by the operation. The vital capacity 1 month after the pneumonectomy was 1,150 cubic centimeters, 45 per cent normal. There was no dyspnœa. Six weeks after operation the patient was allowed to be up in a chair for 15 minutes daily. The bronchial fistula closed spontaneously 9½ weeks after operation, at which time the pleural defect had decreased to a small residual sinus. During the succeeding several weeks the patient was allowed to walk about the ward for 30 minute periods three times daily.

The patient continued to be wholly without sputum until February 19, 1933 (97 days after operation) when she complained of a "head cold." During the next several days purulent sputum appeared in increasing amounts. The previously normal temperature rose to 102 degrees F. Roentgenographic examination made 4 days after the onset of these symptoms revealed a pneumonic infiltration of the right lung with a localized area of abscess formation in the second intercostal space. A roentgenogram 2 days later demonstrated the abscess cavity more clearly (Fig. 6). The patient was not dyspnœic, despite the presence of this abscess in the remaining lung. A few spirochætæ were seen on examination of the sputum and accordingly, an intensive course of neoarsphenamine was started. The patient also recevied postural drainages and carbon dioxide inhalations at frequent intervals. The response to treatment was prompt. Eighteen days after the onset of symptoms, the sputum disappeared. The pneumonitis subsided rapidly, but the abscess cavity decreased more slowly. The vital capacity 3 weeks after the onset of symptoms was 1,320 cubic centimeters, 51 per cent normal. Subsequent roentgenograms demonstrated a gradual improvement of the residual lesion in the right lung.

An electrocardiographic examination by Dr. F. D. Johnston 5 months after operation revealed a sinus arrhythmia with changes in the location of impulse formation, and inverted *T* waves in Lead I with small *M* shaped *QRS* complexes. The *T* wave changes in Lead I may be due to a shift in the position of the heart.

Present condition:[1] At the time of submitting this report, 6½ months after the pneumonectomy and 3½ months after the development of the abscess in the right lung, roentgenographic examination shows a slight residual infiltration in the region of the pre-existing abscess but no abscess cavity can be seen (Fig. 7). The pneumonectomy defect is healed, and the patient (Fig. 8) is without cough or sputum. The vital capacity has increased to 1,415 cubic centimeters, 55 per cent normal. To lessen the possibility of a recurrence of an abscess in the right lung, the patient has not as yet been allowed out of bed.

A review of the literature on experimental pneumonectomy discloses that, in 1881, Gluck first demonstrated that resection of an entire lung could be successfully performed in rabbits. In the following year, Biondi (16) reported 30

[1]Since submitting this report, the patient's convalescence has been entirely satisfactory. She was discharged from the Hospital on December 23, 1933 (13¼ months after operation) at which time her condition was as follows: There had been an increase of 35 pounds (15.9 kilograms) over her weight before the pneumonectomy. She was not dyspnœic when walking, and she had no cough or expectoration. Roentgenographic and physical examinations revealed no evidence of residual abscess or pneumonitis in the right lung. The vital capacity had increased to 1,685 cubic centimeters (63 per cent normal). A letter written by the patient on December 31, 1933, stated that she was without symptoms.

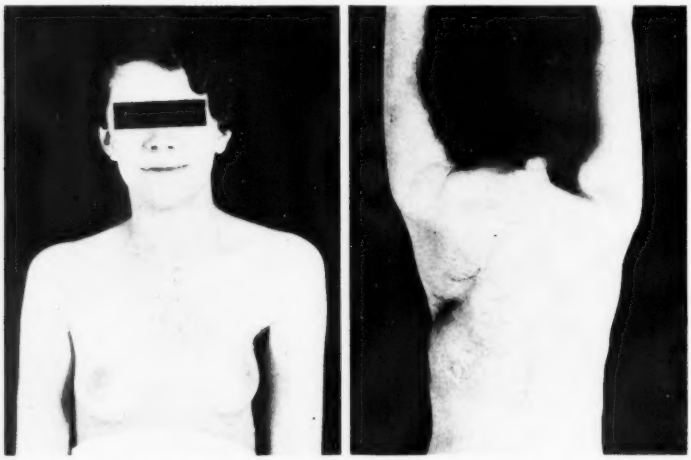

Fig. 8. Photograph of patient 6½ months after total removal of the left lung. The anterior incision was employed for parasternal division of the costal cartilages prior to thoracoplasty. The pneumonectomy wound (upper posterior incision) is healed.

successful complete pneumonectomies in 57 animals. Since then numerous investigators have published reports which were mainly concerned with variations in operative technique. Their results show that the mortality in animals was chiefly due to postoperative pleural effusion and empyema, tension pneumothorax resulting from leakage from the bronchial stump and œdema of the opposite lung. Quinby and Morse believed that the two main difficulties in attempting excision of the dog's lung were adequate closure of the bronchial stump so that it would not leak air, and provision for the compensatory filling of the empty half of the chest by the remaining thoracic organs. Sauerbruch and Robinson were of the opinion that the experimental removal of one lung can be accomplished successfully only when the cavity persisting after the operation is diminished in size as soon as possible, in order thereby to avoid the accumulation of a transudate. Most of the experimental work has been concerned with removal of the normal or healthy lung and the conditions of the experiments were therefore not analogous to the removal of diseased lungs in humans. Schlueter and Weidlein, using Willy Meyer's (28) inversion method of treating the bronchial stump, excised one entire lung in four animals. In two of the three surviving animals, a pulmonary abscess had been previously produced in the lung that was removed. The single death occurred from empyema in an animal in which a gross pleural infection, resulting from the previously established pulmonary abscess, was observed at the time of operation. For a critical review of the literature concerning experimental pneumonectomy, reference should be made to the comprehensive article by Schlueter and Weidlein.

Willy Meyer (10) has emphasized that the experience gathered in experimental pulmonary surgery cannot be directly transferred to the treatment of pulmonary disease in man. Although the experimental removal of an entire lung was performed successfully in 1881 (Gluck) it was not until 50 years later that the first deliberately planned, therapeutic removal of an entire human lung was successfully undertaken (Nissen, 1931).

SUCCESSFUL TOTAL PNEUMONECTOMY

From his observations on pulmonary lobectomy, Nissen, in 1931, planned a technique which he successfully applied in removing an entire lung for bronchiectasis. This is the first successful instance of the complete removal of one lung for therapeutic purposes. A brief summary follows:

The patient, a girl 12 years of age, developed a severe mediastinal emphysema following a crushing injury to the thorax. An immediate incision in the jugulum resulted in liberation of air through the incision. The simultaneous occurrence of a tension pneumothorax left no doubt, according to Nissen, that a tear in the left main bronchus was the cause of the symptoms. An empyema of the left pleura developed and drainage was instituted. During the course of several months the symptoms of a chronic pulmonary suppuration appeared. An abscess, which presented in the third (left) intercostal space near the sternum, was drained. The wound communicated with the left main bronchus. Lipiodol, injected through the fistula, demonstrated bronchiectasis of the entire left lung. A bronchostenosis

resulting from the injury to the main bronchus, was the obvious cause of the pulmonary suppuration. Although the patient's general condition was not good, it was decided to extirpate the entire left lung.

After paralyzing the left diaphragm, an extensive axillary resection of the third to fifth ribs was performed. The extensive adhesions, which were of a veil-like consistency, offered no difficulty in separation of the lung. After the pedicle of the lower lobe had been developed and while endeavoring to isolate the upper lobe, strong traction on the hilum resulted in temporary cardiac stoppage. The operation was discontinued and the entire wound was tamponaded with gauze. The second stage was performed 14 days later. The gauze packing was removed. Beginning peripherally, the upper lobe was freed. A dense adhesion at the apex required division between ligatures. After the entire lung was separated, an elastic tube ligature was tied around the hilum proximal to the bronchial obstruction, and additional silk ligatures were tied peripheral to the elastic ligature. Gauze was again packed around the lung. After operation, the temperature was elevated to 39 degrees C., the pulse rate varied between 140 and 160. On the eighth day, the fever and tachycardia decreased. The necrotic lung sloughed away on the fourteenth day. The residual cavity decreased rapidly in size, being aided by the extreme rise of the paralyzed diaphragm and the marked retraction of the mediastinum toward the side operated upon. Accordingly, a thoracoplastic collapse of the thoracic wall was not necessary to obliterate the pleural space. After 8 weeks there was only a small fistulous tract which led to the stump of the left main bronchus.

Mention should also be made of 2 earlier cases, inasmuch as they have been cited in the literature as instances of complete pneumonectomy.

Sauerbruch's case reported in 1923 (12): In this case, accidental interference with the vascular supply of the left lung during the removal of a large posterior mediastinal tumor resulted in the subsequent necrosis and sloughing of the entire lung.

The patient, a girl of 19 years, was operated on in two stages. At the first stage, an exploratory thoracotomy, with removal of the third to sixth ribs posteriorly, was done. After the seventh and eighth ribs were resected at the second stage, a large ganglioneuroma of the posterior mediastinum was excised. A pleural exudate formed 2 weeks after operation. Four weeks later it became purulent and a rib resection was done to provide drainage. About 8 days later large pieces of necrotic tissue were removed from the pleural cavity with a forceps. They proved to be sequestra of necrotic pulmonary tissue, the largest measuring 12 by 8 by 4 centimeters. Later inspection of the pleural cavity is said to have revealed the absence of the entire left lung. There was no bronchial fistula. It was subsequently necessary to perform a thoracoplasty in several stages, in order to allow the thoracic wall to fall in and close the defect.

Macewen's case: The patient was operated on in 1895 but was reported in 1906. Although mentioned by Nissen (11) and others (4) as being the first case of complete pneumonectomy, a careful review of the case history shows that Macewen drained at the first operation a huge tuberculous cavity which had resulted from an almost complete destruction of the left lung. At several subsequent operations, he resected shreds of pulmonary tissue, but the adherent apex of the lung could not be removed. Obviously Macewen did not actually resect any large portion of the lung. In view of the fact that this case has been misquoted as one of complete pneumonectomy, a detailed abstract of the operation is appended.

At the first operation, performed on April 24, 1895, a large tuberculous pulmonary cavity was drained. "One hundred sixty ounces of pus, along with sloughs of the lung and caseated débris, were removed. . . . By means of the finger and the long probe introduced into the cavity, a dense layer of lung tissue with shreds of disintegrated lung was found still adherent to the chest wall. . . . After 4 weeks . . . it was deemed advisable to perform thoracoplasty, both with the view of thoroughly exploring the cavity and removing the shreds of lung tissue still remaining, and also with the hope of reducing the dimensions of the cavity. . . . Excision of portions of the fourth, fifth, sixth, and seventh ribs was performed. . . . The view obtained . . . was such as to enable one to see that there was no vestige of the left lung remaining, save shreds adhering to the walls of the chest, a portion at the apex and a stump representing the larger bronchi and the corresponding blood vessels, somewhat fused together and covered by granulation tissue. . . . There were several shreds of disintegrated lung tissue still adherent to the diaphragm, to the outer walls of the chest, and to the apical part of the thorax. The former were removed, the latter cut short, their proximity to the large subclavian vessels rendering it undesirable to attempt complete removal. . . . Portions of the third, eighth, and ninth ribs were removed at a later date to further facilitate contraction. . . . After the interior had become aseptic and a layer of healthy granulation tissue had filled the various recesses, the skin was laid over the now thickened pericardium and diaphragm and stump of lung and soon became adherent and filled up the cavity; a small sinus at the upper end persisted, coming from a point where shreds of the apical portion of lung remained. On several occasions, while the cavity of the thorax was still open, attempts were made to detach these, but on each the adhesions were found too firm to permit of easy separation. The adhesions of the apical portions to the subclavian vein precluded further detachment. The loose portions were trimmed." The patient was examined 11 years after operation and he was found to be in good health. Since his operation he had not been ill, he had been regularly at work, and he had walked as much as ten miles without fatigue.

FATAL CASES OF TOTAL PNEUMONECTOMY

The reports of the recorded unsuccessful instances of total pneumonectomy are instructive in that they illustrate the technical difficulties and the operative and postoperative complications that may be encountered. Mention of the cases of Kuemmell (6, 7); Willy Meyer (10), (3 cases); Lilienthal (8), (2 cases); and Archibald (1) will be made. The causes of death and the technique of the operations will be considered in the hope that the experiences gained by these cases may serve as a guide to those who may undertake total pneumonectomy under varying conditions.

Kuemmell's case (1911) is the first recorded instance of complete pneumonectomy in man.

A one stage procedure was employed for resection of the right lung involved in a diffuse carcinoma. The preoperative compression of the lung by a pleural effusion made it unnecessary to resort to differential pressure when the thorax was entered. After the pedicle was clamped, the entire lung was amputated. The clamp was left in place and the pedicle was not ligated. The cause of death in this case is uncertain. In his first report (6), Kuemmell mentions the development of a bronchitis on the third day after operation. Improvement did not occur and the patient died on the sixth day with increasing pulmonary œdema and tracheal râles. Postmortem examination showed the bronchus and pulmonary vessels tightly compressed with the clamp. The pulmonary stump was necrotic, and the pleural cavity and diaphragm were infiltrated with carcinomatous nodules. Fatty degeneration of the liver, a flabby heart, and a diffuse bronchitis were also found. In a subsequent report (7), Kuemmell states that the patient died of sepsis arising from necrosis of the pulmonary stump.

An acute streptococcal septicæmia was the cause of death in a recent (1932) patient of Archibald's (1).

A three stage procedure was employed for the removal of a tumor of the left stem bronchus which had caused a bronchiectasis of the lower lobe. At the first stage, an exploratory thoracotomy revealed no metastases and a preliminary pneumothorax was induced in order to stiffen the mediastinum. At the second stage, the lower lobe was excised because of suppurative bronchiectasis which was caused by obstruction by the tumor. About 2 months later, the upper lobe, together with the stump of the lower lobe bronchus and the stem bronchus, from a point about 1 inch from the tracheal bifurcation, was removed through an anterior incision. The septicæmia that was responsible for the patient's death 4 days after the final operation was thought to have come from a very small empyemic cavity that followed the lower lobe lobectomy.

Archibald concludes from this experience that it would have been better to have removed the whole lung at one stage through an anterolateral incision and by the same technique as he employed for the final stage, provided the mediastinum had first been stabilized by an induced pneumothorax. Kuemmell likewise recommended a preliminary induced pneumothorax. He believed that a pneumothorax, with or without an effusion, would decrease the danger of extirpation of the lung. His deductions were based on his previous experiences with induced pneumothorax as a preliminary measure to the intrathoracic removal of carcinoma of the œsophagus.

Hæmorrhage from the pulmonary pedicle during the individual ligation of the bronchi and vessels resulted in death in one of Willy Meyer's (10) patients, operated on in 1915. While endeavoring to ligate the main trunk of the pulmonary artery during resection of a bronchiectatic left lung, a large hæmorrhage occurred as the ligature was being passed around the artery and as a result, the patient died on the table.

In Lilienthal's (8) first case, 1919, a severe hæmorrhage occurred as a complication during the ligation of the pedicle but the hæmorrhage was not directly responsible for the fatality.

The right lung, involved with an extensive bronchiectasis, was resected in one stage by the chain ligature method. During division of the pedicle, a sudden hæmorrhage occurred from a large vein. Although the opening in the vein was secured with clamps, it was necessary to leave the clamps in place, owing to the patient's desperate condition. Death occurred 6 hours after operation, apparently from œdema of the remaining lung.

Secondary hæmorrhage from the pedicle was the cause of death 13 days after operation in Lilienthal's (8) second case (patient operated on in 1920).

In this case the left lung was resected in two stages because of a post-tonsillectomy suppurative pneumonitis. Tube drainage of the pleural cavity was employed between stages. At the second stage the pedicle was ligated with 6 or 7 transfixion (chain) sutures of strong twisted silk and the entire lung was immediately amputated.

Lilienthal believed that the hæmorrhage occurred from a destructive infection of the wall of an important vessel, probably the pulmonary artery, as the ligatures had already sloughed off at the time of the hæmorrhage.

Œdema of the contralateral lung was responsible for the death of one of Willy Meyer's (10) cases, a boy of 5½ years, operated on in 1920.

A resection of the right lung was done because of bronchiectasis and lymphosarcoma, the latter being discovered on examination of the specimen. After primary clamping of the hilum, the entire lung was amputated in one stage. Careful hæmostasis was obtained by surrounding the pedicle proximal to the clamps with a large, round needle and catgut in sections. In this case, airtight drainage of the pleural cavity was used.

Pneumonia of the lung operated upon, following a first stage operation, was responsible for the death of one of Willy Meyer's patients for whom he had planned a two stage removal of the left lung which was involved in a postpneumonic process.

The totally adherent lung was loosened with difficulty at the first stage, the collapsed lobes were surrounded with gauze, and the wound was closed. Airtight drainage of the pleural cavity was instituted. On the third day after operation, the patient developed difficulty of expectoration with signs of increasing inflammation, which was probably pneumonia, on the side operated upon and he succumbed on the following day. A partial necropsy revealed no evidence of aspiration by the opposite lung. In retrospect, Meyer believed that a one stage procedure might have offered a better chance of recovery.

CONSIDERATIONS OF OPERATIVE TECHNIQUE

In reviewing the cases of complete pneumonectomy mentioned, it can be seen that in 6 of the 7 unsuccessful cases, primary amputation of the lung was carried out. In the remaining case (Meyer), the patient died after separation of the lung at the first stage and before the contemplated removal of the lung at a second stage. In these 6 cases of primary amputation, the following complications were noted. A serious hæmorrhage from the pedicle occurred during operation in 2 instances (Meyer, Lilienthal), one of which was fatal (Meyer). Infection of the pulmonary stump resulted in a secondary fatal hæmorrhage from the pedicle in 1 case (Lilienthal), and it may have been the cause of death in another case, although a bronchitis on the contralateral side was also present (Kuemmell). Œdema of the contralateral lung was the cause of death in 2 instances (Meyer, Lilienthal). In Archibald's case, septicæmia arising from an empyema pocket that followed the lower lobe lobectomy resulted in death 4 days after the removal of the remainder of the lung. Although a primary amputation of the lower lobe had been done, the empyema was not necessarily dependent on the technique that was employed.

Primary amputation of the lung was not performed in the 2 successful instances of complete pneumonectomy (Nissen's and the writer's cases). In these 2 cases, a mass ligature of the pedicle was used and the lung was allowed to slough. Sauerbruch's case should probably be included in this group, as the same result occurred although it was unintentional. It would seem that this method of mass ligature of the pedicle, allowing the lung to become necrotic and sequestrate, minimizes certain complications that have resulted from primary amputation of the lung, i.e., primary or secondary hæmorrhage from the pulmonary stump and infection of the stump. This view corresponds with the conclusions arrived at by Meyer (10) after his several unfortunate experiences with primary amputation of the lung and individual ligation of the vessels and bronchi. Meyer expressed the opinion that the pulmonary stump should be treated *en masse*, inasmuch as he believed that separate ligation of the branches of the pulmonary artery and vein, with airtight closure of the infected and indurated stump was inadvisable or impossible. He did not mention whether immediate amputation of the lung should be done after mass ligation of the pedicle or whether the lung should be allowed to become necrotic and sequestrate. An exception to the use of mass ligation of the pedicle may occur in certain cases of bronchial malignancy in which a greater length of the stem bronchus must be removed than is possible with mass ligation of the pulmonary hilum.

The location of the pedicle ligatures is a technical point that warrants consideration. The ligatures may be placed proximal to the bifurcation of the main stem bronchus, thus removing the entire lung as a unit, or the lobes may be ligated separately. Nissen employed the former method, inasmuch as there was a stenosis of the main bronchus. In the writer's case, despite the presence of a similar stenosis, each lobe was ligated separately, although technically the ligatures could have been placed just as readily at the level of the main bronchus. In most cases of bronchogenic carcinoma, the more central position of the ligatures seems preferable. However, in bronchiectasis or multiple abscess, ligation of the individual lobes, provided they are readily separable, seems advisable inasmuch as spontaneous bronchial closure is more likely to occur with several small fistulæ than with a single larger fistula. By placing the ligatures more distant from the mediastinum, the dangers of reflex cardiac disturbances and injury to the mediastinal structures may be lessened, and organization of the thrombi in the pulmonary vessels should be facilitated.

Although the choice between a one, two, or more stage procedure may depend upon conditions presenting at the time of operation, it is of interest to note that all single stage procedures to date have been unsuccessful, whereas the successful operations of Nissen and the writer were performed in more than one stage. The probability of operative shock must certainly be greater with a one stage procedure which ordinarily requires a longer duration of anæsthesia and more operative manipulation than does either stage of a two stage procedure. The obvious disadvantage of a two or more stage procedure is that the sputum continues after the first stage, thereby increasing the danger of aspiration pneumonia. In this regard, mention has been made of one of Meyer's cases in which death from pneumonia of the diseased lung occurred 4 days after the first stage of a contemplated two stage procedure.

Infection of the pleura should also be considered when choosing between a one stage and a two stage procedure. A one stage removal of a diseased lung exposes the virgin pleural cavity to a grave infection that may prove overwhelming. This danger may be lessened by applying the principles utilized by John Alexander in his two stage procedure for unilobar lobectomy. Alexander stresses preparation of the pleuræ at the

first stage by means of a sterile inflammatory exudate, induced by gentle stroking of the pleuræ with gauze, after the lung has been freed of any adhesions that might be present. This pleural exudate serves as a protective barrier against the inevitable infection that occurs within the pleural cavity after the second stage of the operation. It also aids in stabilizing the mediastinum, thereby reducing the dangers of mediastinal flutter and operative shock at the time of ligation of the pulmonary hilum. Alexander employs mass ligation of the pedicle, allowing the lobe to separate spontaneously.

After a review of the literature concerning experimental (14–39) and clinical total pneumonectomy and from experiences with one stage and two stage lobectomy, I am of the opinion that the principles utilized by Alexander for unilobar lobectomy are applicable, with slight technical modifications, to the removal of an entire lung. By employing these principles, it would seem that the mortality of complete pneumonectomy should be materially reduced. It may be advisable, however, to modify this technique, so that the lung, after its separation, will not become adherent to the thoracic wall, mediastinum, and diaphragm. To accomplish this, the lung may be loosely surrounded with gauze or it may be enclosed in a rubber investment. For this purpose, a suitable thin rubber bathing cap can be readily applied, the bathing cap being securely maintained in position by approximation of its free margins with a single suture above the pulmonary hilum and another suture below the hilum. Although I have not as yet employed this suggestion clinically, I plan to do so if the opportunity presents.

Individual conditions and unforeseen operative developments will necessarily influence the technical procedure in each instance. These variations make it impossible to formulate a standard technique that can be routinely applied. However, it would seem that the technique employed should be planned to anticipate the occurrence of certain complications that are almost inevitable, whereas it should endeavor to avoid other complications that may be preventable. The complications to be anticipated are pleural effusion, infection of the pleura, and opening of the bronchial stump. The complications to be avoided include operative shock, mediastinal flutter, mediastinitis, œdema of the contralateral lung, primary and secondary hæmorrhage from the pulmonary stump, and infection of the stump. From the evidence presented, a two or more stage procedure appears to fulfill these requirements more satisfactorily than a one stage procedure. In the application of a two or more stage procedure, the purpose of the first stage would be to obtain separation of the lung, in preparation for its subsequent ligation at the second stage. The use of continuous airtight drainage of the pleural cavity, instituted at the first stage and maintained until the wound is eventually packed wide open, should obviate the dangers of massive pleural effusion and tension pneumothorax.

PRE-OPERATIVE AND POSTOPERATIVE CONSIDERATIONS

Pre-operative pneumothorax. The use of an induced pneumothorax as a preliminary measure to pneumonectomy has been suggested by Kuemmell (7) and employed by Archibald. Although a pre-operative pneumothorax offers certain advantages, it can not be determined at this time whether it will prove of sufficient advantage to warrant its application as a routine measure. Perhaps its chief advantages are in obtaining a gradual pre-operative collapse of the lung and a stiffening of the mediastinum, both of which should aid in reducing operative shock during the pneumonectomy. An induced or, at least, an attempted pneumothorax will also give an estimate of the probable extent of pleural adhesions. In cases of malignancy, a pre-operative pneumothorax may be of value in determining the operability of the lesion, in that subsequent roentgen examination may reveal evidence of metastases to the mediastinum, pleura, or diaphragm that would otherwise be invisible. In suppurative pulmonary disease, a satisfactory collapse of the lung should reduce the pre-operative amount of sputum and thereby lessen the incidence of aspiration pneumonia. In pulmonary suppuration, and especially pulmonary abscess, the possible occurrence of an empyema as a result of the pneumothorax is a danger that must be seriously considered and which may outweigh the advantages of pneumothorax in this group of cases. As an oleothorax provokes a greater degree of pleural reaction than a pneumothorax, the possibility of converting a pre-operative pneumothorax into an oleothorax suggests itself as a means of further stiffening the mediastinum. The pleural reaction may also be of value in preparing the pleuræ against later infection. However, the advisability of an oleothorax as a pre-operative measure appears questionable at this time.

Thoracoplasty. Thoracoplastic measures may be necessary to provide for the obliteration of the pleural cavity after the pneumonectomy. In some instances, especially in children, thoraco-

plasty may not be needed. This was the case with Nissen's patient, a girl of 12 years. In Sauerbruch's patient, who was 19 years of age, a subsequent thoracoplasty was required. If it should be found that a thoracoplasty is a necessary adjunct in adults, individual conditions would determine whether the thoracoplasty should precede or follow the pneumonectomy. A preliminary thoracoplasty offers certain advantages. Operative shock at the time of the pneumonectomy should be reduced, as the preceding collapse of the lung will have resulted in a gradual shifting of the respiratory function and the pulmonary circulation to the contralateral lung. Furthermore, the thoracoplasty can be performed without contamination from the pneumonectomy wound. Hedblom has emphasized the fact that in bronchiectasis, the thoracoplasty in itself may be sufficient to relieve the symptoms. Because of this reason, a preliminary thoracoplasty was performed in the writer's case. A possible disadvantage of a preliminary thoracoplasty is that it may cause pleural adhesions that would make separation of the lung more difficult. An advantage of deferring the thoracoplasty until completion of the pneumonectomy is that closure of the thoracic defect can be observed, enabling one to determine whether a thoracoplasty will actually be necessary. A further advantage is that the thoracoplasty would be performed after a marked reduction or cessation of sputum, thereby reducing the dangers of aspiration pneumonia.

Scoliosis. As a postoperative scoliosis is a complication that may develop after pneumonectomy, prophylactic measures should be employed soon after operation. This is particularly important in children, in whom the scoliosis may otherwise be severe. A severe scoliosis is to be avoided as it may cause a further decrease in the respiratory function. Postural straightening of the spine and suitable corrective exercises should prove to be valuable measures in the prevention, as well as in the treatment of a scoliosis. The exercises should be planned to develop the muscles on the side of the convexity. Postural correction of the scoliosis can be obtained by having the patient lie on the side of the convexity, over a firmly rolled pillow placed slightly caudad to the apex of the curve (3).

SUMMARY

A case of resection of the entire left lung for bronchiectasis is reported.

The literature bearing on total removal of one lung in man is reviewed. The operative technique employed in the successful and unsuccessful cases is discussed, and the complications and causes of death in the unsuccessful cases are enumerated. Variations in operative technique are critically considered.

NOTE.—The following recent cases of total removal of one lung have come to the writer's attention since the preparation of this article. These cases will be briefly mentioned, in order to bring the literature on total pneumonectomy to date. The cases are listed in chronological order.

1. Reported by O. Ivanissevich and R. C. Ferrari. (La neumectomia en el hombre, Bol. y trab. de la Soc. de Cir. de Buenos Aires, 1933, xvii, no. 13, July 5.) One stage removal of left lung for alveolar epithelioma of bronchus. The neoplasm was apparently a superior pulmonary sulcus tumor. Death occurred 8 days after operation. Operation, October 11, 1932.

2. Reported by E. Windsberg. (Personal communication, January 15, 1934.) Successful multiple stage removal of the right lung for bronchiectasis. This is apparently the second instance of successful total pneumonectomy in man. It is also the first successful case of total pneumonectomy in this country. Cautery pneumonectomy, performed in two stages, was followed by resection of the lung in two stages. Operation, November 8, 1932.

3. Reported by H. Lilienthal. (Pneumonectomy for sarcoma of the lung in a tuberculous patient. J. Thoracic Surg., 1933, ii, 600–611.) One stage removal of left lung for sarcoma. Death occurred 4 days after operation. Operation, January 28, 1933.

4. Reported by E. A. Graham and J. J. Singer. (Successful removal of an entire lung for carcinoma of the bronchus. J. Am. M. Ass., 1933, ci, 1371–1374.) This is apparently the first case of successful removal of an entire lung for carcinoma of the bronchus. It is also the first successful instance of a one stage removal of the lung. Operation, April 5, 1933.

5. Reported by John Alexander. (Personal observation.) Case 1. Three stage removal of the right lung for multiple pulmonary abscesses, for which previous cautery drainage had been unsuccessful. Death occurred 8 days after operation. Operation, June 19, 1933.

6. Reported by E. Archibald. (Personal communication, November 2, 1933.) Successful one stage removal of the lung for sarcoma of the upper lobe and an infective bronchiectasis and pneumonitis in the lower lobe. The patient was reported as being well and the wound healed 3¾ months after operation. Operation, July 7, 1933.

7. Reported by W. F. Rienhoff, Jr. (Pneumonectomy. A preliminary report of the operative technique in 2 successful cases. Bull. Johns Hopkins Hosp., 1933, liii, 390–393; also personal communication, October 9, 1933.) Case 1. Successful one stage removal of the left lung for fibrosarcoma in a child 3½ years of age. Operation, July 24, 1933.

8. Reported by John Alexander. (Personal communication.) Case 2. Successful multiple stage removal of the left lung for bronchiectasis. Lower lobe lobectomy, 1931. Partial resection of upper lobe, July, 1933. Symptoms continued, necessitating removal of the remaining portion of the upper lobe. Operation, October 16, 1933.

9. Reported by W. F. Rienhoff, Jr. (Bull. Johns Hopkins Hosp., 1933, liii, 390–393.) Case 2. Successful one stage removal of the left lung for tumor of the bronchus. Operation, November 3, 1933.

10. Reported by S. O. Freedlander. (Personal communication, January 12, 1934.) One stage pneumonectomy for carcinoma of the left main bronchus. Uneventful convalescence. Thoracoplasty 3 weeks later to close

residual cavity and fistula. Death from pulmonary œdema on following day. Operation, November 4, 1933.

11. Reported by John Alexander. (Personal observation.) Case 3. One stage resection of the left lung for carcinoma of the bronchus. Thoracoplastic removal of upper four ribs and exploratory thoracotomy 5 days earlier. Death from cardiac failure occurred 30 days after operation. Operation, November 6, 1933.

12. Reported by R. H. Overholt. (Personal communication, January 11, 1934.) Successful one stage removal of the right lung for carcinoma. Operation, November 13, 1933.

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DIAGNOSIS AND TREATMENT OF PHARYNGO-ŒSOPHAGEAL DIVERTICULUM

HERMAN J. MOERSCH, M.D., ROCHESTER, MINNESOTA
Division of Medicine, The Mayo Clinic

E. STARR JUDD, M.D., F.A.C.S., ROCHESTER, MINNESOTA
Division of Surgery, The Mayo Clinic

ROKITANSKY, in 1840, divided diverticula into traction and pulsion types. Pulsion diverticula are characterized by a pushing out of the mucosa from the lumen through the muscular coat; traction diverticula by a dragging out of the wall by adhesions of adjacent glands or from structures to the outer side of the wall. Pharyngo-œsophageal diverticula belong to the former type. Ludlow, in 1746, was first to observe and describe such a case. It was assumed that these diverticula originated between the pharyngo-œsophageal juncture, hence the term pharyngo-œsophageal diverticulum. Killian and Keith, however, have demonstrated that they originate between two definite parts of the inferior constrictor muscle. They arise on the posterior wall of the pharynx in the median line at the level of the cricoid cartilage and just above the pharyngo-œsophageal juncture. At this site, weakness is manifest in the muscular wall below the last transverse fibers of the constrictor pharyngis inferior muscle and those lower circular or oblique fibers of the constrictor pharyngis inferior muscle that go to make up the cricopharyngeus muscle. Consequently, the term pharyngeal pulsion diverticulum would seem the more appropriate.

The pharynx, however, gives rise to two other types of diverticula from which the pulsion diverticulum must be distinguished. The first is of congenital origin, and usually is termed pharyngeal diverticulum. It arises from the bronchial clefts, in most cases the opening of the sac is in the vicinity of the base of the tonsil or pyriform sinus. Another type of diverticulum has been described by Moynihan; it arises between a gap immediately below the border of the cricopharyngeus muscle and the fibers of the œsophagus which are descending from their origin at the back of the cricoid cartilage. These have been called lateral diverticula. A few reports of such cases have appeared in the literature; the treatment is the same as that accorded true pulsion or pharyngo-œsophageal diverticula.

Two hundred seventy-six patients with pharyngo-œsophageal diverticula were observed at The Mayo Clinic previous to February, 1933. The condition was found to occur much more commonly among men (227) than among women (49), a ratio of 4.5+:1. It becomes manifest in later life. The average age of the 276 patients was 57.2 years; the youngest patient was aged 31 years, and the oldest 83. Most of them, however, were aged between 50 and 70 years. It was difficult to determine accurately the duration of symptoms, because many patients had become so accustomed to a certain degree of dysphagia that they regarded the condition as normal for them, and only after removal of the sac did they realize the degree of the disability from which they had suffered. The average duration of preoperative symptoms was 6.1 years.

ETIOLOGY

The etiological factors are somewhat obscure. A history of trauma, adenomatous goiter, and stricture of the œsophagus may be occasionally elicited, but these factors seem to be a casual rather than a true underlying cause. The usual description found in textbooks is that, during swallowing, considerable pressure is exerted on the wall of the œsophagus and pharynx, and the inner coat naturally might be forced through the weakened area between the transverse and oblique fibers of the inferior constrictor muscle. However, Waggett and Davis, by the use of water pressure, were unable to find a greater tendency to herniation at this point than in the remainder of the œsophagus. Barclay recently has presented observations to refute the ordinary conception of deglutition and he feels that the creation of negative pressure is of greater importance than the positive pressure in deglutition. Considerable further proof is, however, necessary to substantiate this contention.

Bell, in 1813, first suggested that the origin might be the result of a spasmodic stricture of the musculature in the lower part of the pharynx which caused fasiculations of the muscular layer above the obstruction and hernial protrusion of the mucosa. Jackson more recently emphasized the importance of the cricopharyngeal muscle in the development of pulsion diverticula, and feels it is due to the inco-ordination of the cricopharyngeal pinchcock resulting in failure to open the

upper end of the œsophagus closed by tonic contractions.

The possibility of an embryologic or developmental anomaly as the basis of pulsion diverticula has been mentioned by C. H. Mayo; we are inclined to consider such origin possible since several of our patients with pharyngo-œsophageal diverticula had complained of difficulty in swallowing from early childhood. Jackson has reported similar experience. Unfortunately, no definite roentgenological evidence is available to substantiate such an hypothesis, primarily because sufficient evidence has not been elicited to warrant roentgenological examination. One of us (Judd) has noted that dimpling ordinarily appears in the mucosa at the point where pulsion diverticulum occurs. It is conceivable that such dimpling in these cases is more marked and assumes the form of a very small pouch, thus providing the proper anlage for development of the diverticulum. It is assumed that incoordination of the cricopharyngeus muscle, increased intrapharyngeal pressure, decreased elasticity of the tissues with increasing age, and the constant accumulation of material in the pouch would facilitate its development. However, these factors, in the absence of such a developmental anlage, would probably fail to produce pulsion diverticulum. Evidence in support of this hypothesis is presented by a case reported by Rush and Stingly of a large congenital diverticulum which was found to be present at birth and which arose from the posterior lateral wall of the œsophagus at the level of the cricoid cartilage.

The sac of a pharyngo-œsophageal diverticulum is composed primarily of the coats of the mucosa and submucosa, and, as has been mentioned, is due to the herniation of these layers through the muscular wall (Fig. 1). Muscle fibers do not compose an integral part of the sac, as is seen in traction diverticula. They may, however, project a short distance on to the neck of the pouch; only rarely are strands of muscle found extending across its surface. The caliber of the neck of the sac usually remains small and tends to invade the superior mediastinum; it seldom projects below the arch of the aorta. Owing to the anatomical relationship of the œsophagus to the cervical portion of the spine the diverticulum tends to appear on the left side of the neck, although occasionally it may appear on the right side; determining the situation aids in the selection of the site of exposure for removal of the sac, as it is best removed on the side of the neck toward which the diverticulum inclines.

SYMPTOMS

The symptoms produced by pharyngo-œsophageal diverticulum are characteristic, and consist primarily of dysphagia, regurgitation, and the production of a typical gurgling noise on eating, speaking, or on pressure over the sac when it is distended with air or food. The onset is usually insidious and consists of a dry, scratchy feeling in the back of the throat and a tendency to the accumulation of mucus. Granular foods are especially difficult to swallow. The degree of dysphagia tends to increase with the size of the sac and may progress to complete obstruction which may terminate fatally. Small diverticula, however, are occasionally encountered which may give rise to more difficulty than those of considerable size. Solid food generally causes more difficulty than liquid, although considerable variations may be displayed. The dysphagia has been thought to result from the pressure of a distended diverticulum on the posterior wall of the œsophagus. Other factors, however, are of far greater importance. Lahey has emphasized that "in the beginning the diverticulum is on the lateral wall of the œsophagus and remains in this position as long as it is of small size. When, however, the sac increases in size so that considerable food lodges in it, the traction and weight of the food in the sac so pulls on the neck of the sac that the opening of the diverticulum gradually changes from a lateral to a transverse position, the true opening into the lower portion of the œsophagus below the neck of the diverticulum assumes such a lateral position that it becomes difficult if not impossible for food to enter it." Jackson also pointed out that the action of the cricopharyngeus muscle adds to the degree of dysphagia, and Halstead stated that by its action the lower border of the neck of the sac forms a valve that may project into the lumen of the œsophagus and close it when the sac is full. Figure 2 demonstrates that the twisting which occurs with the change of position of the sac from mesial to lateral might tend to increase dysphagia. The influence of the mechanical factors mentioned can be readily demonstrated at operation, since simple elevation of the base of the sac completely relieves dysphagia. However, should too great traction be exerted obstruction again occurs.

Regurgitation is prone to occur when the sac has become large enough to retain liquids and food, and it also tends to become more marked with increase in the size of the sac. It is particularly likely to manifest itself with the patient in the prone position, which produces strangulation and cough. This constitutes a definite risk,

Fig. 1. Mucous membrane herniating through muscular coat and forming diverticulum.

for material regurgitated during sleep may be aspirated into the lungs and give rise to pulmonary suppuration. Because of the cough the patient may be treated erroneously over a long period for tuberculosis or pulmonary suppuration before the true nature of the disease is discovered.

A peculiar clicking or crackling sound while the patient is speaking or eating is characteristic of the condition and is usually present. It can be produced in practically all cases by having the patients swallow and then make quick pressure over the sac. The sound is produced by the sudden expulsion of air from the diverticulum into a resonant chamber. This sound may become very annoying and with regurgitation causes patient to avoid eating in company or public places.

Large pharyngo-œsophageal diverticula may produce swelling with a sensation of pressure at the base of the neck, particularly on the left side, with swallowing. It also produces hoarseness due to pressure on the recurrent laryngeal nerve. Loss of weight varies with the degree of dysphagia and the duration of symptoms. When the obstruction is marked, loss of weight may be considerable.

DIAGNOSIS

Although the diagnosis of pharyngo-œsophageal diverticulum can usually be readily made from the clinical history, further confirmatory evidence is essential. This can be obtained by roentgenological examination, passage of sounds according to the method of Plummer, and œsophagoscopy. The roentgenological examination will reveal the presence of the sac. It is necessary, however, to keep in mind the possibility of such lesions as a carcinoma high in the œsophagus

Fig. 2. Change in position of sac from mesial to lateral caused by twisting.

or stricture with obstruction and dilatation above the obstruction, which may closely simulate diverticula. Although the mucous membrane of a diverticulum seldom undergoes carcinomatous change, it was found in one of our cases, and the possibility of such change must always be considered. Attention has been called to the necessity of ruling out before operation is undertaken any other œsophageal lesion that might be present, such as cardiospasm, which we found in 4 cases. Crile and Dinsmore reported the case of a patient with carcinoma and cardiospasm, associated with pharyngo-œsophageal diverticulum. In practically all cases additional information is readily obtainable without risk by the passage of sounds as advocated by H. S. Plummer and Vinson. Should further information seem advisable, œsophagoscopy should be performed.

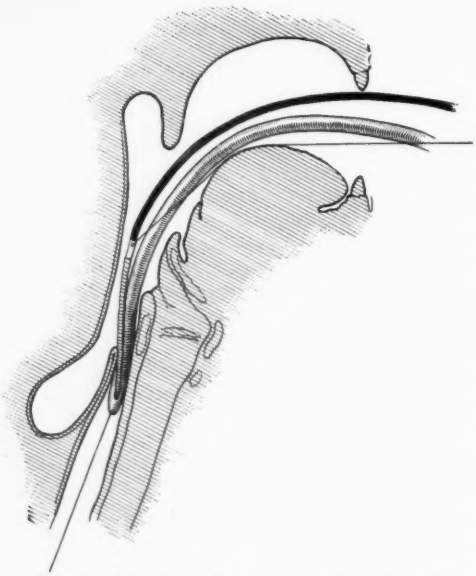

Fig. 3. Method used for passage of stomach tube.

TREATMENT

The treatment of pharyngo-œsophageal diverticulum is primarily surgical. In certain cases, however, palliative measures seem indicated, particularly if patients are advanced in years and if the sac is small and producing few if any symptoms. Palliative measures must also be resorted to when the patient is in such poor condition that immediate operation is inadvisable.

The periodic passage of sounds, a thread always being used as a guide, frequently affords considerable relief. This is done for the purpose of stretching the opening into the œsophagus and overcoming any existing spasm of the cricopharyngeus muscle. Lahey especially recommended this procedure as a postoperative measure to prevent recurrence of the diverticulum. It is particularly valuable if there is a tendency for spasm of the œsophageal introitus following operation.

If patients are being treated by palliative measures, they should be instructed to evacuate the pouch thoroughly after meals and at night before retiring. This tends to keep the sac clean and overcomes the risk of aspiration into the lung.

To avoid increase in risk, palliative procedures should be carried out in cases of marked œsophageal obstruction, dehydration, and malnutrition before operation is undertaken. Gastrostomy is advocated, but should be avoided if possible because of the high mortality of this normally simple operation on patients markedly dehydrated, or those advanced in years. The procedure which we have found most satisfactory, and have described, is the passage of a Sawyer tube over a previously swallowed silk thread as a guide (8). It is surprising with what ease a patient with marked obstruction is able to swallow a thread. In many cases, however, the physician is called on to exercise considerable patience before this feat is accomplished. Certain patients are better able to start the thread with the sac of the diverticulum filled with fluid; others are more successful when it is empty. Patients are able to swallow the thread in from 1 to 2 days, during which time they should receive fluids and nourishment intravenously, and by proctoclysis. We have observed only 2 patients who were unable to swallow the thread. When the thread is safely anchored, a Sawyer type of tube can be slipped readily into the stomach. The use of a whalebone staff with a special guide (Fig. 3) facilitates the passage of the tube, as snubbing at the introitus may prevent the flexible catheter getting beyond this point. The tube can be left in place or removed after each feeding. Such procedure soon brings the patient into a condition suitable for operation. Imperatori has suggested the ingenious method of inversion of the sac by grasping its bottom, inverting it into the pharynx, and ligating the base, permitting it to slough off. Although the diverticulum usually lies loosely in the tissues of the neck, it may be surrounded by a dense fibrous wall (Fig. 2), so that the risk of attempting invagination is readily apparent. Division of the common wall between the diverticulum and the œsophagus has also been suggested, but the procedure carries considerable risk.

We usually carry out the operation in two stages, both of which are done under local anæsthesia. The first stage consists of freeing the diverticular sac by dissecting it from the surrounding tissues in the neck and mediastinum. Then, after it has been completely separated from the surrounding structures, it is left prolapsed to the outside of the neck. The sac is sutured in this position by the use of a few stitches to attach it to the sternomastoid muscle and other muscles of the neck. The cavity from which the diverticular sac was removed is left without drainage. The second stage is done 8 days after the first. At this time the sac is loosened from the surrounding tissues by blunt dissection carried on down to the œsophagus. After this is completed, the sac is clamped off and is removed and the

neck of the sac is sutured over. In the event the diverticular sac is large, it is much safer to do the operation in two stages. This causes the patient very little additional inconvenience.

The recent trend has been to do the operation in one stage if the sac is small. With this plan the sac is removed at the first operation. Apparently this can be carried out safely provided it is not necessary to continue the dissection down into the mediastinum.

Whenever it is advisable to remove a small diverticular sac in two stages, two silk sutures are passed through the outer wall of the fundus of the sac and are brought to the outside and allowed to project through the wound to facilitate finding the sac at the time of the second stage of the operation. These sutures do not pass through the mucosa of the sac and are not tied down into the tissues. It seems best not to fix the sac to any of the tissues for the reason that the effort of swallowing or muscular pull from coughing is likely to cause the sac to break at the point of fixation.

On a few occasions following removal of the œsophageal diverticulum, there has been a slight tendency toward constriction of the œsophagus. However, this is not a frequent experience and we do not pass a sound after the operation unless it is evident that there is some constriction.

Some of our patients have had fistula from the œsophagus for a while. In no instance has it been necessary to institute surgical treatment to obtain closure of the fistula although on a few occasions the fistula has persisted for a considerable period. Passing sounds into the œsophagus has seemed to hasten the healing of these fistulas.

The most serious risk is encountered in dealing with the elderly patient who has other difficulties in addition to the condition in the œsophagus, and who nevertheless must have the diverticulum removed because of increasing interference with swallowing. Were it not for this group of elderly patients there would be no occasion for serious trouble following removal of the œsophageal diverticulum.

One hundred seventy-seven of the 276 patients under our observation were operated on. That the surgical treatment is not without a certain element of risk is shown by the fact that among the 99 patients not operated on there were 3 who died before examination or operation could be instituted. One patient died from spontaneous perforation of the diverticulum into the mediastinum with bleeding. Death occurred apparently within the space of a few minutes. A second patient died from apoplexy and a third from starvation. That a certain degree of risk must be anticipated, no matter what type of surgical procedure is used, is apparent from the ages of the patients treated, their poor general condition, and the frequency of associated pulmonary infection. This is illustrated by the two postoperative deaths from coronary infarct, while the operative field was in excellent condition, but still these deaths must be charged to the surgical procedure. The comparative safety of surgical extirpation of the sac is illustrated by the fact that we have been able to operate on 57 consecutive patients without a death, and on another series of 41 without untoward results.

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CONSERVATIVE TREATMENT OF ACUTE DUODENAL FISTULA

ALBERT E. McEVERS, M.D., F.A.C.S., Rock Island, Illinois

WITHIN the last decade, there has been established a very definite and satisfactory management for the clinician who is called upon to treat acute duodenal fistula. It is the purpose of this paper to summarize the treatment and offer some additional suggestions.

McGuire, in 1920, reported doing a jejunostomy of the Witzel type and feeding the patient by the introduction of food at a point below the fistulous opening. He did not claim the procedure to be original, but stated that he was unable to find reference to it in the literature. Erdman, in 1921, advocated jejunostomy, jejunostomy feeding, and suction. Cameron, in 1923, and Lahey, in 1924, reported the treatment of duodenal fistula by suction. Potter's article, published in 1927, described a method of destroying the potency of the intestinal juice by neutralizing its alkalinity and taking care of the excess by supplying a protein and fat combination in sufficient amounts to use up the juice before it could attack the tissues of the abdominal wall. Haden and Orr's experiments demonstrated the body needs for fluids, chlorides, and dextrose. The work of Walters and Bollman called attention to the changes in the blood resulting from duodenal fistula, and the toxæmia of duodenal fistula. Other authors have added to the management by suggesting modifications of technique and naming several types of buffer solutions.

REPORTED MORTALITY

Colp, in 1923, reported a series of 61 cases of duodenal fistula, the gross mortality being 61 per cent. Of these cases 36 were treated conservatively, with a mortality of 60 per cent. He stated that gastro-enterostomy with pyloric occlusion gave a mortality of 85 per cent. The largest series of duodenocutaneous fistula was reported by Bohrer and Milici in 1931. They included 61 cases reported by Colp in 1923, and 44 cases collected by themselves—105 cases in all. They gave a combined mortality of 37 per cent of all the cases reported.

Kittelson, in a recent review, reported a series of 94 cases from the literature, and 2 of his own. Of this series, it was shown that 65 cases were treated conservatively with a mortality of 27.7 per cent; 30 cases were treated by surgery with a mortality of 50 per cent. The mortality of all groups, including all types of treatment, was 35.8 per cent.

The mortality of cutaneous duodenal fistula and the rapidity of its ravaging destruction is well known. The toxæmia results from loss of acid and chlorine in the gastric and pancreatic juice discharged from the fistula. Resulting chemical changes in the blood are an increase in alkalosis, decreased concentration of chlorides in the blood serum, and a progressive rise of blood urea. This toxæmia, with fluid loss and inanition, may speedily cause death if corrective measures are not properly instituted. These systemic effects, with the additional local results that are produced by the proteolytic action of trypsin in the pancreatic juice, with its extensive erosion and excoriation, render this condition an emergency where prompt and correct management is essential.

Concerning the mortality rate of 27.7 per cent in the 65 cases treated conservatively (reported by Kittelson), it is hoped that this will be considerably reduced by added clinical experience and our improved knowledge. It is shown in the table that the etiological factor was as follows:

	Cases
Following operation on the gall bladder	30
Following operation for perforated duodenal ulcer	22
Following operation for nephrectomy	8
After resection of stomach from malignancy	8
After operation for acute appendicitis with obstruction	7
After rupture of the duodenum	6
From other causes	7

In the 22 cases following operation for perforated ulcer, the 6 cases after rupture of the duodenum, the 8 cases following resection of the stomach from malignancy, 7 cases after operation for acute appendicitis with obstruction, a total of 43 cases, one could have well included a jejunostomy with the primary operation. It was definitely indicated in the 22 cases following operation for perforated duodenal ulcer.

A well functioning jejunostomy, done at the time of the primary operation, becomes invaluable should duodenal fistula become a surgical complication. Duodenal fistula generally develops from the fourth to the ninth day after operation.

TREATMENT

Surgical. Extensive surgical procedures are contra-indicated for the treatment of duodenal fistula, because of the high mortality rate following. Jejunostomy, however, can be done with a mini-

mum risk and can immediately be used for the introduction of food and chemicals into the lower bowel. It should be made with a valve-like control (the Witzel or Kader methods), which can be done without danger of leakage into the peritoneum. Potter has called attention to the fact that a simple jejunostomy made with a pursestring suture has, in itself, created most irritating duodenal fistulas.

Medical. The objectives of medical treatment are

1. Chemical, nutritional, and fluid loss replacement.
2. Nutritional maintenance.
3. The buffer action of food and solutions to render the proteolytic action of the trypsin innocuous to the fistulous tract and skin.
4. Protection of the skin by applications to prevent erosion.
5. Strapping of the discharging sinus to lessen the loss of duodenal secretion.

The fact has been established by experimental work and clinical results, that the chemical and fluid loss can be replaced and maintained. Sustaining nourishment can be administered by the subcutaneous and intravenous administration of salt solution and glucose. Additional nutrition may be given in sufficient amounts by feeding through the duodenal or jejunostomy tube. The Levine duodenal tube is useful if it can be passed beyond the fistulous opening of the duodenum, or it may be used in the event that the jejunostomy does not function well.

The corrosive action of the duodenal secretion is chiefly due to the pancreatic component. Erdman recommended the dilution of this secretion with large amounts of water by mouth, and diluting the sinus secretion and flushing of the fistula. Potter acidulated the secretion in the sinus with tenth-normal hydrochloric acid solution and applied a preparation of beef to the skin, soaking gauze with it and applying it to surround the fistulous opening. The crater left in the center of this gauze dressing was filled with one to three drams of tenth-normal hydrochloric acid solution. The outside of the gauze was made adherent to the skin with liquid adhesive, or gutta-percha was laid to the skin through the application of chloroform; thus he kept the beef juice and acid confined to the area to which it was to be used. The idea was to have the pancreatic juice digest the beef juice, also to inactivate the pancreatic juice by action of acid upon it, based on the fact that trypsin functioned better in an alkaline media.

Howell has shown that trypsin is capable of digesting the tissues of the abdominal wall when the fistulous discharge is acid. He also noted that the closer the fistula is to the pylorus, the greater the tendency to be acid. Clinical observation of this fact is mentioned in the literature (Salmon and Gambill).

Suction. Suction could be used to advantage to carry away the secretion, if it were not for the difficulty of its application. It is not necessary, provided the dressings can be changed frequently. Zinc oxide ointment or kaolin powder applied thickly, protects the skin from the secretion that has previously had contact with the buffer solution.

Open treatment and exposure to light. The wound may be left open 2 to 4 hours twice a day and the whole abdomen exposed to the rays and heat from a 750 watt carbon bulb with a large reflector bowl. The actinic rays and heat are healing to the macerated skin. Secretions from the wound can flow away to the side, into fluffed dressings. The digestive action of the trypsin is greater when it is in contact with the skin on secretion-soaked dressings.

Drainage. Cushing has shown that the normal stomach can be bacteria free if sterile food is fed for 24 hours. Infection high up in the gastrointestinal tract is practically absent; however, following perforated duodenal ulcer, infectious peritonitis may often result. These facts are important in the consideration of drainage to be used, following operation for perforated duodenal ulcer.

Penrose tube drain without gauze, applied through a stab wound in the right flank, into the peritoneal cavity and placed so as not to be near the line of suture in the repaired duodenum, may be advantageous. The stab wound will serve admirably for drainage in the event that fistula does occur (Fig. 1). The opinion gathered from the literature indicates that drainage should not be used.

Buffer solutions. Erdman, in 1921, used milk powder, glucose, and olive oil mixed with the entire secretion from the fistula, for two-hourly eight-ounce jejunal feedings. Potter mentioned using boiled milk. He stated that in addition to its constipating effect, it supplied intra-intestinal protein for the digestive action of pancreatic juice, and tended to cut down the excess. From 4 to 6 ounces of boiled skimmed milk were given by mouth every 4 hours. However, Potter stated: "The keynote of the treatment is the local application of tenth-normal hydrochloric acid and sterile beef juice." Kittelson used whole milk, thickened by the use of acidophilus placed locally in the wound and fistula, with tenth-normal hy-

TABLE I

Composition, dry	Per cent	*Composition of normal dilution*	Per cent
Fat	27.0	Fat	3.37
Protein	16.0	Protein	2.0
Lactose	18.7	Carbohydrate	6.54
Maltose	17.4	Salts	0.41
Dextrins	16.2	pH	7.2
Salts	3.3	Measurements and food values:	
Moisture	1.4	1 ounce = 151 calories	
To prepare normal dilution; 1 oz. in 7 oz. water.		4 packed level tbsp. = 1 ounce	
		1 oz. fluid normal dilution = 19 calories.	

drochloric acid applied by means of a catheter. The milk solution was prepared by taking whole milk repasteurized, then cultured with acidophilus, and kept warm for 6 hours.

In the case I am reporting, as in others, ingested material soon appeared in the fistulous discharge. This fact inspired an attempt to buffer the tryptic action of the secretion before its exit from the duodenum. Reliquefied recolac was selected as a buffer agent for clinical trial because of the simplicity of preparation. Boiled milk, acidophilus milk, or any reliquefied milk concentrate could be used with the same result. Table I shows the composition of recolac dry, and the composition of the reliquefied normal dilution as compared to breast milk and cow's milk, shown in Table III.

How to prepare. The amount of previously boiled water needed is warmed to about blood heat; the prescribed number of level tablespoonfuls of recolac are put on top of the water and beat with an egg beater or table fork until dissolved. The utensils used in the preparation are previously sterilized.

If powdered protein milk were used, it could be boiled when reliquefied, to render it sterile. The normal dilution gives the following formula (Table II); it has a high protein content which is desirable. Fats or oils could be added to increase its fat content.

Method of recolac administration.

1. Six ounces are given by mouth every 2 hours for eight times in 24 hours, a total of 48 ounces, with food value of 912 calories. At first, most of the feedings given are returned through the fistulous opening.

2. Eight ounces are given every 2 hours for eight times by the jejunostomy tube, a total of 64 ounces in 24 hours, with a caloric value of 1,216 calories.

Note. The mouth and tongue were thoroughly cleansed twice a day and an antiseptic mouth wash was used before every feeding.

TABLE II.—COMPOSITION OF NORMAL DILUTION

	Per cent
Protein	3.25
Lactose	2.00
Butter fat	2.20
Salts	.50
Lactic acid	.25
Water	91.80

Hydrogen ion concentration pH 4.80
1 fluid ounce = 12 calories.

TABLE III

Breast milk	Per cent	*Cow's milk*	Per cent
Fat	3.5—4		3.5 —
Protein	1.5—2		3.3 — .5
Lactose (sugar)	.6 —7		4.6 — .8
Salts	0.2— .25		0.65— .75

CASE REPORT

A. E. F., a male of 39 years, admitted to the hospital July 15, 1933. He reported good health except recurrent attacks of dyspepsia with food and soda relief for the past 4 or 5 years. Present attack occurred suddenly at 3 a.m. while asleep. Pain was severe; his family physician was called and a diagnosis of perforated peptic ulcer was made. Family history was irrelevant. He arrived at the hospital in shock; intravenous infusion of 1000 cubic centimeters of 10 per cent glucose in salt solution was administered. He was operated on shortly after being admitted.

Under ethylene anæsthesia the peritoneal cavity was opened. A perforation 0.5 centimeter was found in the anterior wall of the duodenum. The opening in the duodenum was closed with Pagenstecher's linen and the wound covered with a piece of omentum. A jejunostomy of the Witzel type was done, and a stab wound made in the upper right quadrant, in which two drains of Penrose tubing were inserted. Postoperative diagnosis was perforated duodenal ulcer; postoperative condition was good.

Continuous hypodermoclysis was started when the patient was returned to bed; 1000 cubic centimeters of 10 per cent glucose in salt solution was given intravenously. First, second, and third days after operation were uneventful; the fourth day, the duodenal fistula developed. At first, there was a slight discharge noted on the dressings which appeared to be duodenal secretion. The amount of this discharge gradually increased on the fifth, sixth, seventh, and eighth days after operation. Only slight tryptic action was manifested up to this time. On the ninth day, the duodenal drainage became enormous. It appeared that the entire duodenal contents were discharged through the sinus. The skin became inflamed, eroded, and macerated. Most of the drainage came through the stab wound in the right flank; discharge also came through the upper end of the incision which had opened, and around the silkworm-gut retention sutures. The edges of the opened-up incision were acutely inflamed.

The jejunostomy tube, which had been clamped off until now, was used for feedings. One thousand cubic centimeters of 25 per cent glucose and 1000 cubic centimeters of 4 per cent salt solution were injected at intervals. The eleventh day the dressings were changed every half hour and the skin was protected with zinc oxide ointment and kaolin powder; but the skin became more excoriated and painful beyond endurance. At this time, jejunostomy tube and oral administration of reliquefied recolac were used. Six ounces of this milk mixture were given by mouth and

8 ounces by enterostomy tube every 2 hours for 8 doses daily. Intravenous glucose of 10 per cent solution, which had been given every other day, now was given daily and hypodermoclysis was continued. Treatment remained the same from the twelfth to seventeenth day. Some of the milk powder solution presented itself at the fistulous opening as it was being injected into the jejunostomy tube. About one-third escaped through the opening and about two-thirds found its way to the lower bowel. This could be more or less regulated by the speed with which it was injected.

The wound was left open about 3 hours twice a day and the whole abdomen exposed to the rays and heat of a therapeutic light. The discharge from the wound drained to the side into fluffed dressings, which were changed when soiled. The fistulous opening was strapped tightly with sterile adhesive and zinc oxide ointment applied to the skin. By the eighteenth day, there was very little drainage, and none on the nineteenth day, when the patient was allowed to sit up in a chair (Fig. 2). From the twenty-second to the thirtieth postoperative days, the milk powder feedings were continued, and in addition, a glass of eggnog was given by mouth every 4 hours. On the thirty-first day the enterostomy tube was removed and the patient was up and about; the thirty-fourth day the wounds were all healed and the patient was discharged from the hospital.

Note. There was duodenal drainage from the fourth to eighteenth postoperative days, slight at first, with no tryptic action manifested until the ninth day when there was profuse drainage. The amount of discharge was estimated about 2 liters per day. Following the administration of the buffer milk solution, there was immediate improvement. Drainage continued and gradually stopped on the eighteenth postoperative day.

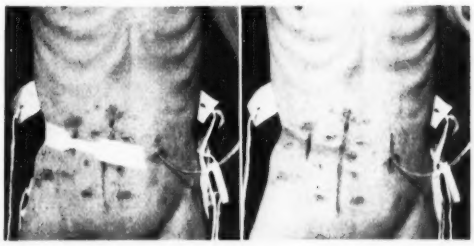

Fig. 1, left. Illustrating the case of control of drainage by strapping, when bulk of the fistulous discharge makes its exit through a stab wound.

Fig. 2. Taken on the nineteenth postoperative day. Fistula healed.

SUMMARY OF MANAGEMENT OF CONSERVATIVE TREATMENT

The treatment under consideration applies only to the acute duodenocutaneous fistula. Small chronic fistulas, duodenocolic fistulas, and other internal fistulas are not taken into consideration here.

The anticipatory treatment.

1. Such a large percentage of acute duodenal fistulas follow perforated duodenal ulcer and known traumatism to the duodenum, that it seems feasible to establish a well functioning jejunostomy at the same time that the primary operation is being performed.

2. The building up of the nutritional and chemical reserve by administering: (a) Continuous hypodermoclysis of normal saline solution, (b) daily intravenous infusion of 10 per cent glucose in salt solution, a liter a day for several days after any operation entailing the suturing of the duodenum; thus the patient is systemically prepared for the rapid toxæmia and inanition, should the formation of a fistula ensue.

3. Avoidance of drainage material when possible. If drainage material is used, it should be soft rubber drainage material of the Penrose type, without gauze, through a stab wound in the right flank. It should be placed in such a manner that it is distant from the suture line in the duodenum.

After the fistula is evident.

1. As has been noted in some cases following duodenal surgery, there is a slight seepage of what appears to be intestinal secretion. Very little proteolytic action upon the skin and tissues is shown at first, but suddenly there may be a copious discharge, representing probably the entire duodenal secretion. Immediate treatment for duodenal fistula should be instituted when fistula is suggested by the first appearance of the duodenal secretion. One should not wait until the drainage becomes profuse.

2. Replacement of chloride and sodium ions and fluids by intravenous and subcutaneous saline administration.

3. Nutritional maintenance by administering: (a) Intravenous glucose, (b) feedings through the jejunostomy or duodenal tube, (c) feedings of reliquefied milk powder of 8 ounces every 2 hours, for eight times, injected into the jejunostomy tube. Concentrated glucose solution can be added if additional nourishment is needed; also, concentrated saline solution to aid in chlorine replacement, and lubricants to aid in elimination of the lower bowel.

4. Administration by mouth of 6 ounces of reliquefied milk powder every 2 hours, for eight times daily, for its buffer effect on the proteolytic action of the duodenal secretion, before it leaves the duodenum.

5. Strapping of wound. Tight strapping of the fistulous opening of the abdominal wall, provided there is no free pus in the discharge. After the straps are applied, care should be taken so that the skin is protected from the secretion. This can be accomplished with zinc oxide ointment or kaolin powder.

CONCLUSIONS

1. That a buffer solution of milk, milk modification, or reliquefied milk concentrate given by mouth at frequent intervals will

a. render the duodenal secretion less innocuous to the sinus, abdominal wall, and skin before it leaves the fistulous opening in the duodenum;

b. dilute the duodenal secretion which has been buffered by the oral administration of milk to the extent that it will lessen its proteolytic action on the skin or soft tissues;

c. thicken the duodenal secretion. It has been noted that the greater the fluid content of the discharge, the more irritating it is to the tissues of the abdominal wall.

2. When the reliquefied milk powder solution is given by mouth, it is not necessary to use tenth-normal hydrochloric or other acids to lessen the alkalinity of the duodenal secretion; nor is it necessary to use oil or fat in addition to the amount it contains.

3. The principle of tightly strapping the fistulous opening in the abdominal wall with adhesive plaster should be energetically employed.

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EDITORIALS

SURGERY, GYNECOLOGY AND OBSTETRICS

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APRIL, 1934

CONCERNING THE SUTURE

WHEN Galen recommended a ligature of Scottish linen thread which could be bought at a certain shop on the Via Sacra, he displayed one of the attributes of a surgeon; that is, fastidiousness in the selection of the materials with which he works. Unfortunately, in the case of the suture, this more often rests upon tradition or intuition than upon knowledge or insight into the problems involved. Even in these days of the scientific method, surgeons swear by or at various types and kinds of sutures without any material reasons for the opinions which they express. Yet, the reasons for using a suture and the conditions which surround its employment seem almost axiomatically apparent. It should not be difficult to select the kinds of material and the way to use them.

The first necessity is obviously tensile strength, but strength apportioned to the functions which the suture is supposed to perform rather than to the physique of the operator. In general, these functions are the binding of blood vessels, the relief of tension, and the approximation of tissues.

In the first instance, the object to be achieved is the staying of the flow of blood until the vessel becomes firmly thrombosed. The force required for the closing of even a major vessel, as one can determine by compressing the radial, is not great, in fact less than five pounds. Even the lightest ligature has this much strength. Failure comes not from breaking of the ligature but from its being slipped by the pulsation of the vessel. This may be avoided by applying a crushing mass ligature in which case it must be so strong that it can scarcely be broken by the operator. Preferable, however, is the application by transfixion of a light ligature which produces much less destruction and leaves less non-living material in the wound. With the small "spurters" ordinarily encountered, transfixion and tie, or tie alone, with the finest ligature available is ample assurance against further bleeding.

In the second group, it is a generally accepted principle that sutures the function of which is to carry tension, should not be used in the wound itself for approximation. These are of necessity heavy and non-absorbable and preferably impermeable. Therefore they must be removed, but only after the danger period of 10 to 14 days is over. Such heavy material buried in the wound will in most instances lead to delayed healing, abscess formation, and in many instances extrusion of the suture material.

Lastly, it is equally apparent that the approximation of tissues must be obtained without tension on the line of healing. If tension is unavoidable, this must be taken up at points at a distance from the incision. The question

here is what size and type of suture should be used in holding the tissues in approximation, and the answer is obviously the lightest which will serve this purpose. Certainly, it is stupid to use one which is stronger than the tissue through which it passes. Fascia will rarely sustain a suture pull of more than five pounds and this is likewise true of tendon, while "C" twisted silk of a standard grade has a tensile strength of six pounds and "oo" catgut an equivalent amount. Any sceptic may readily test this statement *in vivo* by passing such a suture through either fascia or tendon and pulling until it breaks or pulls out—it will be the latter. If this is true for these dense tissues, it is much more so for muscle and fat, and one is not justified in using anything but the finest sutures in these structures. To employ, as is customarily done, heavy braided silk or No. 2 catgut in approximating wounds is as unintelligent as mooring a rowboat with a ship's cable.

One may answer, however, that there is no harm in using heavier material and thus playing safe. Unfortunately, safety is not increased by doing this but rather decreased. Any suture material has two faults which cannot be entirely avoided. The one is that it acts as a nidus for infection frequently present in the wound or perhaps more frequently on the operator's gloves by reason of his having handled the skin. The larger the suture, the more difficult it is for the scavenger cells of the body to reach these organisms and overpower them and if not absorbed the situation persists indefinitely. This is the peculiar defect of the unabsorbable suture, so if used, as little as possible must be put into the wound. In other words, one must employ only the finest twisted silk with interrupted rather than running stitches, square knots cut on the knot, and taking only small bites of tissue. The other objection to the use of heavy sutures, that of tissue irritation, applies only to the absorbable type, for the customary non-absorbable material such as silk or linen by reason of its lack of absorption is not changed in the tissues and therefore is non-irritating. Wherever it is taken to be such, there is infection present, as in Lister's original experiment which gave origin to the idea that silk was a tissue irritant. On the other hand, when one studies in section even the finest suture of absorbable material, there is always present some degree of reaction about it, for the process of absorption involves the breaking down of collagen into soluble protein or protein derivatives which excite an inflammatory reaction. When the mass of the material present is small, this is inconsequential, in fact less than that entailed in the trauma by the incision itself, but as the mass increases, the situation soon reaches a seriousness comparable to the presence of an hæmatoma or of gross necrotic tissue. Under these circumstances, sterile abscesses may be found and if the suture lies at all near the surface, it or at least the knot may be extruded. Less obvious but none the less true is the more rapid decline in the strength of the suture in the presence of such increased digestive reaction. With infection, the whole process is accelerated so that the strength of the suture quickly disappears but in contrast to the non-absorbable suture leaving no nidus to shelter the organism present.

From this consideration, one arrives at certain conclusions. The surgeon should not use a size of suture material materially greater than the holding power of the tissue involved. This will diminish in the unabsorbable suture the "nidus effect," in the absorbable suture the irritating results of its digestion. The non-absorbable suture should be used only in case asepsis is impeccable, and in such a fashion as to leave only isolated, minute bits

of suture material. The absorbable suture, while not rendering refinement of technique any the less desirable, permits rougher handling of tissues, a certain degree of infection and a grosser but more rapid technique, without in most instances materially increasing the disability of the patient. On the other hand, the non-absorbable suture enforces meticulousness on the part of the surgeon so that he becomes more of the artist, though none the less a craftsman.

SAMUEL C. HARVEY.

PAINFUL LESIONS OF THE SPINE

KNOWLEDGE of the pathologic conditions that underlie painful back is slowly increasing. Probably no single contributor has done more in recent years to advance this knowledge than has Schmorl. His work "Die Gesunde und Kranke Wirbelsäule im Röntgenbild" covers the subject in a comprehensive but concise manner. Many of the facts have been known for a long time, but Schmorl has elaborated on them so as to bring about greater understanding of their importance.

The intricate structure of the spine, together with the difficult approach to it, from the viewpoint of pathology, have prevented its receiving its share of attention in the advance of medical knowledge. Pathologists are seldom interested in studying it unless it has some very obvious lesion. They will take great pains to recover the spinal cord for study, but they seldom save any portion of the spinal column itself. It is to be hoped that with the coöperation of orthopedic surgeons, more efforts may be made to improve on existing knowledge of the spinal column, through direct study of pathology, correlated, when possible, with clinical facts.

The importance of pathologic conditions of the intervertebral disks in the production of symptoms has gained widespread recognition. Perhaps this has been overemphasized, as is natural when interest in a subject is widespread. It is known that the nucleus pulposus can be, and is, ruptured in many cases, without apparent symptoms. Undoubtedly, however, there are cases in which rupture causes definite symptoms. The erosion or narrowing of this disk in many cases of lumbosacral strain is now recognized, and the same type of narrowing may be seen in all parts of the spine, in cases of traumatic or other types of arthritis. Enlargement of the disk is another condition observed in nearly all cases in which the vertebral bodies are extensively involved by disease, and particularly when the diseases are those which produce extensive osteoporosis. Some writers claim that this process is an inflammatory one, involving the disks themselves. The more plausible explanation is that the reduced strength of the bodies allows expansion of the disks to take place, in some cases to extreme degree.

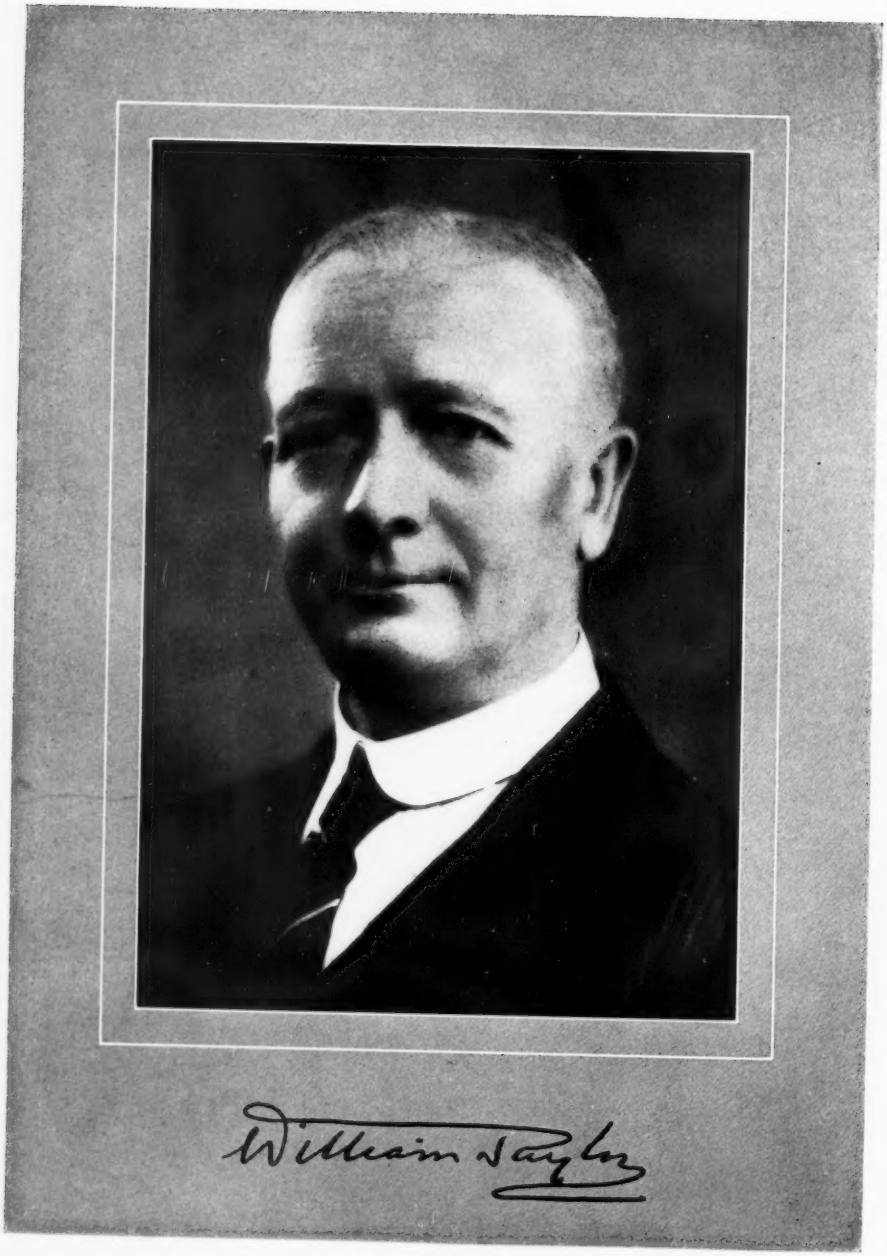
The destructive lesions of the vertebral bodies are fairly well recognized and understood. With present methods in roentgenology, much can be read from a well made roentgenogram. There is, however, a group of cases which can be recognized, but the etiology of which is obscure. These are the cases in which there is a painful condition of the spine, and in which there is roentgenologic evidence of varying degrees of osteoporosis with, in many cases, pathologic fractures of one or more vertebræ. Some of these no doubt are due to osteomalacia, and perhaps some are due to parathyroid tumors; in either case other bones are involved as a rule. In other cases no apparent involvement of other bones can be demonstrated, but the spine may be extensively involved.

The attempt to throw all of these cases into the category of changes in bone resulting from hyperparathyroidism has failed. While the parathyroid glands have a very important function to perform in calcium metabolism, yet present knowledge does not permit all of these atrophic lesions of bone to be so catalogued. One easily can surmise that the condition mentioned may in some way be connected with disturbances of the parathyroid glands, but when these cases are thoroughly analyzed no evidence is found in the laboratory data of any undue excretion or retention of calcium. In the light of present knowledge, therefore, we can presume only some remote connection between this condition and the parathyroid glands.

One cannot regard the spine as being composed only of bone and cartilaginous disks. The more one studies the spine, the more one must be impressed by the importance of the articulations of the posterior bony structures which compose what is commonly known as the neural arch. These are true joints which have three functions; to allow movement to take place; to act as stabilizers to prevent forward slipping of the vertebræ on each other, and to form a part of the protective bony cage around the spinal cord and nerve roots. Their structure and function is such as to subject them to many stresses and strains. For this reason, traumatic arthritis may involve many of these joints. One has only to examine a small series of spines to be impressed with the changes which take place in these joints, changes which must, in many instances, produce symptoms.

In order to recognize the presence of these changes, one must admit the presence of traumatic arthritis, an entity the existence of which many investigators have denied. The preponderance of the results of careful investigation is in favor of the belief that there is such a condition. It can be produced experimentally. Anyone who frequently operates on joints of man must admit the presence of changes which can be ascribed only to traumatism. Articular cartilage is present over all moving joint surfaces. It acts as a cushion and smooth, gliding surface. Strangely enough it has no blood supply, so that repair takes place slowly and inadequately. Degeneration of the cartilage, except under certain conditions, is likewise slow. With its degeneration, however, permanent change appears, and the joint which is subjected to this change is never quite normal again. It is the cartilaginous change in these joints of the spine which is primary. Bony changes come secondary to these, but once established, the joint is more vulnerable than before; it will function normally under average stress or strain, but under abnormal stress or strain reaction takes place, followed by symptoms.

These three types of lesions are among the more recently recognized causes of painful conditions of the spine. Their importance may at present be overemphasized, yet in many instances it is perhaps through overemphasis that proper recognition of the importance of a fact is obtained. Once this is recognized the fact becomes established in more or less common knowledge and receives adequate recognition. R. K. GHORMLEY.


William Taylor

MEMOIR

SIR WILLIAM TAYLOR

THE sudden death, January 30, 1933, of Sir William Taylor of Dublin, an honorary Fellow of the American College of Surgeons, came as a great shock to his many friends over the world.

Sir William was born in County Donegal, September 21, 1871, and received his early education at The Strabane Academy. His later academic distinctions and his long service at the Meath Hospital have been recorded in the *Lancet*, as follows:

"Sir William Taylor, in the medical schools of the Irish Royal Colleges and the University of Dublin proved himself a distinguished student by securing the gold medal of operative surgery and the Mayne scholarship. From the University of Dublin he received the M.B. degree in 1901, having previously secured the F.R.C.S., Ireland. He was appointed assistant surgeon to the Meath Hospital in 1898 and as full surgeon in 1900. He was consulting surgeon to this hospital at the time of his death, so that he had given it life-long service."

Many honors were accorded Sir William in his own country, and last year, 1933, he was to serve as president of the surgical section of the British Medical Association which met in Dublin. He was elected to the Council of the Royal College of Surgeons in Ireland, and in 1914 was vice-president and president in 1916. On the outbreak of the war he was accorded the rank of colonel, Royal Army Medical Corps. He was one of the surgeons to the Dublin Castle Red Cross Hospital, and at the request of the War Office he organized a hospital in France, selecting the staff from men too old for rigorous service. During the war he was indefatigable, and his energy and skill while working with the "83 (Dublin) General Hospital" at Boulogne was recognized with the C.B. in 1917 and the K.B.E. in 1918.

In 1922, Sir William became Regius Professor of Surgery at Dublin University, and in 1923 surgeon to Sir Patrick Dun's Hospital. He was president of the Association of Surgeons of Great Britain and Ireland in 1924–1925 and was president of the Royal Academy of Medicine in Ireland in 1927. In addition to his posts at the Meath Hospital and at Sir Patrick Dun's Hospital, he was consulting surgeon to the Coombe Lying-in Hospital, the Stevens Hospital, and the Dental Hospital of Ireland. As was said in the *British Medical Journal*, "Few

men can have combined so many important posts or acquitted themselves in their multifarious obligations with greater ability."

The papers which he presented before various meetings in North America, and his contributions to medical and surgical literature were obviously based on large experience, and this, with his sound common sense, gave great weight to his opinions in many fields of clinical surgery. Those who have been privileged, as I have been, to visit his surgical wards at Sir Patrick Dun's Hospital, and other hospitals of Dublin, will recall the wide range of his surgical knowledge, his technical skill, his directness, and his forceful teaching. These qualities in a man of his engaging personality made such visits never to be forgotten.

William J. Mayo, in speaking of a visit to Dublin in 1923, wrote of Sir William as "a gifted teacher and surgeon." Dr. Mayo continued, "I have heard him give a graphic description of infantile intussusception, stressing the sudden crying out of the child, the pallor, the vomiting and the explosive movements from the bowels. In none of his cases has he had recurrence after operative reduction. In performing splenectomy in cases of anæmia he immediately transfuses the free blood in the spleen to the patient. He has had noteworthy success in handling cases of acute obstruction of the bowel, using a high enterostomy, with two tubes, for the purpose of emptying the toxic contents of the bowel, and of nourishing the patient."

Honors came to Sir William not only at home, but abroad and it was on the occasion of his first visit to this continent that he was made an Honorary Fellow of the American College of Surgeons at the meeting in Montreal in 1920 and he gave the Fellowship Address that year. It was at this time that Sir William, Sir Berkeley Moynihan, and Mr. A. Carless, representing the Consulting Surgeons of the British Armies in the World War, presented the Great Mace to the American College of Surgeons.

Sir William was elected an Honorary Member of the American Surgical Association in 1924, and in 1927 the degree of LL.D. was conferred on him by McGill University. He had a real admiration for American and Canadian medical schools and teaching and the affection in which he was held by the surgeons of these countries was fully reciprocated. His great personal charm, vivacity, wit, friendliness, and exuberant good health made him always welcomed as a visitor in America by his many friends in and out of the medical profession. Those who had the privilege of knowing Sir William Taylor can understand the tribute of a colleague who wrote of him: "Honest in his work, honest in his dealings with all men, and fearlessly faithful to his convictions, his passing is a tragic loss to his profession and to his country." DONALD C. BALFOUR.

EARLY AMERICAN HOSPITALS

"OLD BLOCKLEY"

TEMPLE FAY, M.D., F.A.C.S., PHILADELPHIA

WOVEN into the history of the Philadelphia General Hospital is the inception and evolution of American medicine. "Old Blockley," as it is familiarly known to many of the profession, has exerted an influence on the entire field of medical and institutional development in this country. The first organized unit for the care of the sick and needy to be founded on the American continent, it has continued its unique position of leadership as an institution of its kind, even to the present intensely modern era.

Every member of the American profession enjoys some common bond which links him to the traditions and early influences of this source and center of medical education. "Old Blockley" has come to assume the place in American Medicine that Independence Hall holds as a shrine in our national and political history.

Twenty-nine years after the landing of William Penn and the founding of Philadelphia, the Monthly Meeting of the Society of Friends, set aside two city lots, each 51 feet by 260 feet, on the south side of Walnut Street between "Delaware Third and Fourth Streets" (4) for the use of poor members of the Society of Friends. Several stone cottages were built for the care and comfort of their impoverished members, and in 1729 a larger building was added on Walnut Street which became known as the Friends Almshouse.

Coincident with this early provision for the poor by members of the Society of Friends, and probably stimulated by their example, there arose the need for care of those who were not members of the Society and yet presented an urgent problem of civic responsibility.

"In 1712 Councils passed a resolution which declared; The poor of the city, 'Daly Increasing, it is ye opinion of this Council that a workhouse be immediately hired to Imploy poor P'sons and sufficient P'sons appointed to keep them at work'"(5).

In 1729 the city recommended the application for relief and the Legislature resolved to "loan the Mayor and Commonality, one thousand pounds to be applied to the purchase of ground and the erection of an Almshouse or Hospice for the use of the poor of the city.

"The money was received in 1730, and a square of ground known as the Green Meadow, bounded by Third and Fourth, Spruce and Pine Streets was purchased from Alden Allen, for two hundred pounds, and a brick building was erected in 1731 or 1732 known as the Philadelphia Almshouse, which was to house the poor, the sick, infirm and the insane"(5).

This became the first large structure in America to be set aside for hospital purposes and although combining the Almshouse until 1919, the evolution of a hospital service such as is enjoyed today, was an object and example which founded the basis of our modern concept of hospitalization. Sir William Osler states:

> This venerable institution, originally the Philadelphia Almshouse, which in 1742 was "fulfilling a varied routine of beneficent functions," has just claim to be the oldest hospital in the States. Having migrated twice during the growth of the city, it finally, in 1834, moved from the "Bettering House" in what is now the heart of Philadelphia, to a farm in the suburbs in the then township of Blockley on the West side of the Schuylkill. Here, far out in the country, the indigent poor and afflicted, the alcoholic and insane of Philadelphia came to be housed—"went over the hills to the poorhouse."

It was the selection of the latter site, known as "Blockley" and named by Captain Warner in 1658 after his old home in England, later to become Blockley Township, which gave to the present institution its familiar sobriquet.

Rich have been the contributions of this oldest American institution for the care of the poor and infirm. Although the records of its early years are obscure, it must be borne in mind that its influence and possibilities in the teaching of medicine were appreciated long before the American Revolution. Agnew (1) states:

> In 1742 it was fulfilling a varied routine of beneficent functions in affording shelter, support, and employment for the poor and indigent, a hospital for the sick, and an asylum for the idiotic, the insane, and the orphan. It was thus dispensing its acts of mercy and blessing when Pennsylvania was yet a province and her inhabitants the

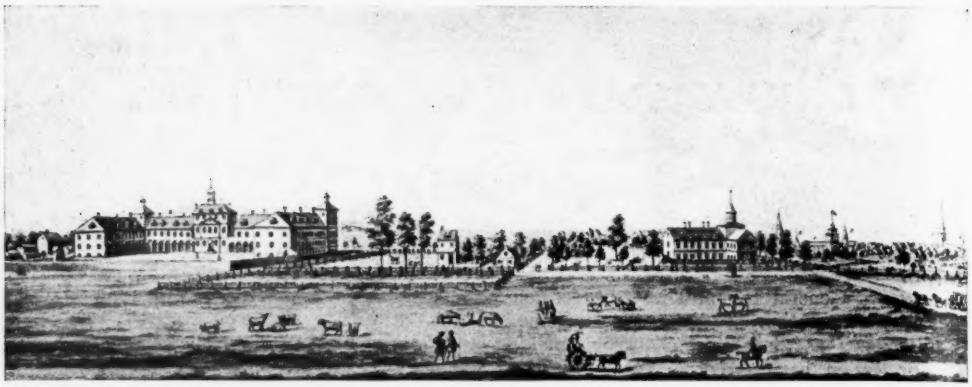


Fig. 1. House of Employment, Almshouse and Pennsylvania Hospital, from an engraving by Hulett. (From Packard, Surg., Gynec. & Obst., 1932, lv, 126.)

loyal subjects of Great Britain, more than twenty years before a school of medicine was founded in this city, and indeed before most of the great events which have given the American people a historical importance among the nations of the earth.

The Pennsylvania Hospital was founded in 1753, as a private institution affording the best medical care to the acutely ill which could be established at that period. The parallel course that these two institutions maintained throughout their years of service has been a constant source of stimulation to each.

It must be borne in mind that the leading physicians of that day attracted to themselves one or more pupils who learned the art of medicine through personal instruction and completed their medical courses abroad, returning to take up their practices in Philadelphia, imbued by the teachings and knowledge of the great medical centers, particularly that of Edinburgh.

Thomas Bond, Cadwalader Evans, Adam Kuhn, Benjamin Rush, John Morgan, and William Shippen were among the leading minds of the profession at that date. It seemed almost inevitable that with the hospital facilities afforded by the Philadelphia Almshouse and the Pennsylvania Hospital, the move toward instruction in clinical medicine should have been given impetus and that there should have evolved the desire for a medical school.

In 1766, Bond is credited with delivering the first clinical lectures in medicine and surgery at the Pennsylvania Hospital. In 1770, and perhaps even earlier, Cadwalader Evans and Bond established the first obstetrical clinic at the Philadelphia Almshouse for "students of good character," and in 1772, the managers were solicited to extend the medical conveniences of the house for better accommodations of the students. Thus the Philadelphia Almshouse, as it was then known, became linked with the teaching of medicine from its earliest days. The care of its inmates was placed in the hands of the leading physicians of the time. With the founding of the department of medicine, College of Philadelphia, the first medical school arose on this continent. The teachers of medicine as members of its staff have found a fertile field for clinical research that has given rise directly and indirectly to the great contributions of American medicine.

The Medical School of the College of Philadelphia, later to become the University of Pennsylvania School of Medicine, was organized in 1765 by Doctors John Morgan and William Shippen. On March 25, 1774, Adam Kuhn, professor of materia medica and botany in the Medical College, and Benjamin Rush, who held the chair of chemistry, and Samuel Duffield, one of the ten Alumni who received the first medical degree on the 21st of June, 1768, and Girardus Clarkson and Thomas Parke were added to the staff of the Philadelphia Almshouse, and this was probably the origin, in this country, of gratuitous professional service to the public, confined to charitable institutions.

It will be seen that the valuable clinical material among the 350 persons then housed within the confines of the institution became the basis for clinical teaching and the source from which the American-schooled physicians found their first concept of applied medicine.

Those who passed through this early training received the benefits of clinical observation from the Philadelphia Almshouse, and in the years

Fig. 2. Aerial photograph of Philadelphia General Hospital. (Through the courtesy of Dallin Aerial Surveys, Philadelphia.)

that followed, many of these men who graduated in medicine from the University of Pennsylvania became the founders of other medical institutions throughout the country, wherein the importance of their early training and experience was handed on to other generations or became interwoven into the rapidly spreading fabric of American institutions and the subsequent progress of medicine which progressively followed in the wake of this early source of learning.

It is interesting to note that Cadwalader Evans, in 1771, recognized twenty-one children within the institution who had not suffered as yet from small-pox, and petitioned the Board of Managers for their isolation and inoculation. The privilege was granted by the Board with the understanding that no expense would be involved other than the cost of the medicines used.

On September 5, 1776, the Managers of the Bettering House, as it was then known, received a request from the Council of Safety to permit the quartering of a number of Continental militia who were very sick with dysentery. This request was strenuously opposed by both the Managers and the medical attendants, as calculated to endanger the health of the inmates, but military possession was taken of the Almshouse in spite of these protests, on October 23, where the troops remained until 1777 when the British took possession of the city and forced their removal. General Howe immediately appropriated the entire east wing of the Hospital for the care of the King's troops. The poor and dependent were driven to the west wing, which the managers attempted to prevent being taken over in a similar manner through the good offices of Joseph Galloway. However, about nine o'clock at night, in November, 1777, orders were received to clear the west wing for the reception of the King's troops. The Board of Managers, meeting next morning, refused to comply with the request, but the British proceeded at once to remove the inmates, about two-hundred miserable, decrepit, and half-starved creatures. These would soon have perished from exposure had not the managers succeeded in securing quarters for them in the Freemason's old lodge, the Friends' Meeting House, and in Carpenter Hall where they were maintained until the last days of June, 1778, following the evacuation of Philadelphia by the British. Of the original two-hundred who were ejected from the building, only eighty-two survived to re-enter their former quarters. During this unsettled period, teaching had been abandoned as is evidenced by the petition received in November of 1778, when a formal application was made to the physicians of the Almshouse for permission to witness the practice in the institution. Their petition was at first denied, but upon reconsideration of the subject at which time the advantages of hospital instruction to the profession in the community were presented, they urged at least a probationary trial and through the efforts of Doctors Rodgers and Leib, who volunteered a personal responsibility for the good conduct of the young men in attendance, the decision was reversed, and the Bettering House was opened by a majority of one vote for a continuation of clinical instruc-

tion. During this year forty additional children were inoculated for small-pox and isolated; all successfully recovered.

On March 5, 1780, an outdoor relief was instituted for those who were not inmates of the house, yet who were dependent upon the institution for relief, and in 1781, the records seem to indicate that Samuel Duffield appeared to be the only attending physician, under conditions as they existed at that time.

In 1787 the Reverend Manasseh Cutler published in his Journal (Vol. I. pp. 253–285) his experiences while visiting the hospital with Dr. Girardus Clarkson, then a member of the staff. He writes,

> We returned to Philadelphia, between ten and eleven o'clock. When we came to the hospital, Dr. Clarkson left me and went into the city on his son's horse. Young Mr. Clarkson conducted me into the hospital, (the young Mr. Clarkson referred to is in all probability the William Clarkson who later became a member of the staff). Doctor Rush arrived in a few minutes after. The building is in the form, as you approach it from the city, of an inverted T. It is surrounded with a high wall, and has back of it a very large kitchen garden. The door in the center opens into a large hall. On each end are apartments for the nurses, cooks, etc. We ascended the stairway out of this hall into another hall in the second story, at one end of which is a large room, which contains a fine medical library, where the directors were sitting, and a smaller room where the medicine is placed. On the opposite end are the apartments for the attending physicians. The third floor is formed in the same manner. On one side of this hall is the Museum, where there is a collection of skeletons and anatomies.
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> After we had taken a view of the Museum, we returned to the upper hall, where several physicians and all the young students in physics in the city were waiting. Doctor Rush then began his examination of the sick, attended by these gentlemen, which I judged to be between twenty and thirty. We entered the upper chamber of the sick which is the leg of the T. It is a spacious room finely ventilated with numerous large windows on both sides. There were two tiers of beds, with their heads toward the walls, and a small chair and a small table between them. The room was exceedingly clean and nice, the beds and bedding appeared to be of good quality, and the most profound silence and order were preserved upon the Doctor's entering the room. There were only women, and about forty in number. Doctor Rush makes his visits with a great deal of formality. He is attended by the attending physicians who give him account of everything material since he saw them last, and by the apothecary of the hospital who minutes his prescriptions. We next took a view of the maniacs. Their cells are about ten feet square, made as strong as a prison. On the back part is a long entry, from which a door opens into each of them. From this distressing view of what human nature is liable to, and the pleasing evidence of what humanity and benevolence can do, we returned to the room where the doctors were. The scene I had now been attending upon was totally the reverse of at Gray's, but such is the elegance of these buildings, the care and attention to the sick, the spacious and clean apartments and the perfect order in everything, that it seemed more like a palace than a hospital, and one would almost be tempted to be sick, if they could be so well provided for. We then took a view of the bettering house, which is a large and spacious building with good room and well furnished.

In 1788, a system of residentship was established which was the forerunner of our present system. The medical department was reorganized and an apothecary appointed. An epidemic of small-pox broke out within the institution, in spite of the rigid observance of isolation, the outcome of which became one of the sad chapters in the history of this great institution, as vaccination had not as yet been discovered and the idea of inoculation was in general public disfavor.

In 1789, clinical teaching at the hospital was discontinued because of the hostile attitude assumed by the Board of Managers, and in this year appointments were made from the house students who served both to dispense medicines and attend the patients on the wards.

In 1793, the great epidemic of yellow fever broke out in Philadelphia, and more than 17,000 of its inhabitants fled the city. Thousands upon thousands of cases occurred, and a large plot of ground, now Washington Square, was used as a Potter's Field, and to this day contains the bones of those who passed their few remaining days within the wall of the Bettering House at the height of this epidemic.

In 1798, yellow fever again visited the city, and more than 50,000 inhabitants left because of its disseminating activity. Whooping cough also reached the proportions of a pestilence at this time.

In 1802, three apothecaries were in attendance at the Hospital and a system of junior and senior physicians was then introduced. Yellow fever again appeared in the community, but because of strict quarantine measures the incidence of cases was confined to only a few. During this quarantine the resident pupils were forbidden to visit the city proper.

In 1803, the first ward instruction was permitted and permission granted to Doctors James and Church to attend the lying-in wards and entertain one private student at each case of labor. On March 23 of this year, Dr. Caldwell was allowed to instruct a class of twenty, later forty students during his visits to the medical wards. He was made responsible for the conduct of the students, who, at that time, were generally regarded with suspicion. On October 25, 1805, a fee of eight dollars was charged for instruction given to the visiting physicians, although office pupils of the attending staff were permitted to receive instruction free.

In November, 1806, the managers granted the privilege of delivering clinical lectures twice a week in the Green, or "Dead House," during the winter season. Dr. Barton was given permission to lecture to his classes on his days of attendance. It is interesting to note that in this year, the former prejudices of the Board of Managers had greatly lessened and their desire turned toward making provisions for more adequate care of the sick and better institutional possibilities. They petitioned the State Legislature for aid and cited that "The Pennsylvania Hospital, rich in estates, had repeatedly received assistance from the munificence of former legislatures, and was at that time before the assembly for help; and yet its doors were closed against the poor, and more than an equivalent for board and lodging exacted." The Almshouse, on the other hand, not only cared for those who came from the city and county of Philadelphia, but one-fifth of the inmates were from other parts of the Commonwealth. Besides, the Almshouse containing over one thousand inmates, presented an extensive field for communicating medical instruction to students attracted to it from all parts of the country by the celebrity of the school (2).

On May 9, 1808, a medical library was started and one hundred and fifty dollars appropriated for the purchase of books. The senior resident physician was made librarian. A second appropriation of one hundred and fifty dollars followed in 1810. This year was noteworthy for the admission of the first female resident, a Mrs. Lavender, a midwife to the Bettering House.

In 1811, additions were made over the "dye and wash house" to permit two wards of twenty or thirty beds each and one lecture room to be added, and the lectures were later held in these new quarters. In 1813, the first discordant note arose in the form of rivalry between the Pennsylvania Hospital and the Almshouse. Success of the Almshouse as a medical school became handicapped because the Managers ruled that anyone holding an appointment on the Pennsylvania Hospital Staff was disqualified from holding a similar one at the Almshouse. This type of petty discrimination has its frequent counterparts in medicine of our day, which clearly shows that beneath the surface, a feeling of rivalry and jealousy had made its appearance among the various members of the two prominent hospital staffs. Students holding tickets were permitted to attend a case of labor at this time. Three hundred dollars was expended for books for the library and a fee of thirty dollars permitted life privileges for use of the library.

Small-pox broke out to alarming degrees in the city of Philadelphia during 1823, and a special house on Bush Hill was provided for the care of those suffering from this dreaded disease. This represents the first inauguration of an isolation or contagious hospital in this country, and is historic because of the direct interest and personal service rendered by Stephen Girard.

In 1824, competitive examinations were instituted for candidates desiring house positions, and in 1827, the privilege was granted to Doctor Thomas Harris to deliver didactic courses in surgery, although not connected with the clinical instruction of the institution. In this year Dr. Horner presented the library with 120 theses from Edinburgh. There were approximately seventy-five students in attendance at that time.

In 1829, Dr. Gerhard, a member of the staff, perfected the thoroughness of physical examination and exploration by means of auscultation and percussion, and he is considered the father of this technique in America. It was on January 1 of this year that the site of the Hospital was purchased from Henry Beckett and his wife for the sum of $51,528.12½. This tract was in Blockley Township, and as mentioned before, the name "Blockley" was bestowed upon this region by Captain Warner who settled it in 1758.

In 1832, an outbreak of cholera led to closing of the hospital doors to new cases, and the nurses then in attendance became so panic-stricken that they were replaced by Sisters of Charity, who remained in the institution until 1853. A card of admission, still in existence, calls for admission on August 22, 1833, and although the new buildings were not occupied until October 1 of this year, this was supposed to be the first card of admission issued for the new building. In 1834, two hundred and twenty students were in attendance, and the revenue derived from this source amounted to one thousand four hundred twenty dollars.

Jefferson Medical College which had been organized in 1825 had grown into considerable importance and a request was made, in the year of 1834, to the Guardians of Blockley to allow the students of Jefferson Medical College an equal status with those of the University of Pennsylvania, in regard to clinical teaching. The trustees of Jefferson Medical College asked for two wards, one medical and one surgical, and alternate weeks for their clinical lectures. Those representing the interests of the University objected to such an arrangement as calculated to mar the harmony of the school and the hospital. They declared that they had undertaken the development of a clinical school at a time when scarcely a ticket

was sold, and that they had succeeded in making it a source of revenue to the Board.

In 1835, it is noted that the day of instruction was changed from Wednesday to Saturday in order to accommodate the men from Jefferson Medical College, numbering seventy-nine students, who sought clinical instruction at Blockley. In this year, the need for a definite name for the institution was recognized, and Mr. Hansel, a member of the Board, proposed that it be called the Philadelphia Hospital. This recommendation was seconded and the medical department of the hospital has been known by this name since that time.

In 1836, the library contained 3000 volumes and proved to be the finest collection of ancient and modern medicine and surgery probably in existence at that time. Doctor Gerhard demonstrated, after careful study of intestinal lesions, the differential points between typhus and typhoid fever.

In 1841, an addition was made to the hospital for the care of infectious diseases, the building being located on the west side of the main structure. Here patients might be observed and those suffering from contagion isolated.

The importance of the school as a great clinical center in America had reached a high point in 1845. The lecture room was capable of holding from 700 to 800 persons, and yet, the teaching of clinical medicine at the Philadelphia Almshouse was abruptly interrupted for a period of 9 years because of the unceremonious slaying of a cockroach at the steward's table by the student physicians then boarding within the hospital. To quote from Dr. Agnew, the incident throws some light upon the hospital, its organization, and its direction at that time. He states (6):

> The 30th of June, 1845, is somewhat memorable in consequence of the culmination of a trouble which had been developing for some time. The resident physicians were boarded at the table of the steward, where, as I understand, in consequence of the want of due formality and decorum in the destruction of an unfortunate cockroach which had rashly taken a near cut across the table instead of going around, these gentlemen became indignant, and demanded of the managers to be transferred to the table of the matron. Their refusal to comply with this request determined a unanimous resignation, leaving the hospital unprovided with any medical assistance. The evening of that day, Doctors Horner and Clymer attended and prescribed for the sick. Here was a *casus belli*, and the managers promptly passed a resolution of dismissal.
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> With the hope of adjusting these differences and bringing about a partial reconciliation, a joint meeting was called for July 2nd, at which Doctors Jackson, Horner, Clymer, Gillingham, and Pancoast attended, representing, as a committee, the medical board. Doctor Jackson, who seemed to have been the advocate in the case, spoke in behalf of the committee, urging the managers to allow the residents to remain, at least until their places could be properly supplied, declining to pass any censure or interfere in any matter of personal conflict between the residents and Guardians, as foreign altogether to their legitimate jurisdiction. The Guardians, however, were inexorable, and refused to recede from their vote of dismissal, thus forever closing the doors of compromise. The seceders, after retiring, availed themselves of the columns of the *Ledger* newspaper in which there appeared a card betraying, to say the least of it, a good deal of youthful indiscretion.
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> On the same day of this meeting, Mr. Flanagan offered the following resolution; "Resolved, That the hospital committee be requested to look into the expediency of reorganizing the medical department of the house, and report to this board." On the 21st of July the report was made, which, after going over the ground of the trouble, recommended the abolishment of the medical board and the substitution of a chief resident and assistant resident physician, and two consulting physicians and surgeons. On the 15th of September the report was taken up and passed, modified as follows:—"After the first of October, 1845, there shall be one chief resident physician, with a salary of $1800 per annum; one consulting surgeon, one consulting physician and one consulting accoucheur, each at a salary of one-hundred dollars a year."
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> What great results proceed from small and unlikely causes! Who would have ever thought that the official existence of a medical board, composed of ablest men in their various departments on the continent, could have depended on the life of a contemptible cockroach? In this manner the doors of the Philadelphia Hospital, as a school of instruction, were sealed for nine years.

During this interval, in 1851, the hospital admitted the first woman physician to its staff in the person of Doctor Sarah Adamson, appointed May 25 of that year. Subsequent attempts were made to return to the medical board system and abolish the position of chief resident physician, but these failed of accomplishment.

In 1854, the doors of the hospital were again opened to clinical instruction and the event was celebrated by the students throughout the streets of Philadelphia. Tickets to the clinics were fixed at ten dollars including transportation for two days a week for four months. Arrangements were made with the railroad which ran cars from Broad and Market Streets to a point opposite the buildings to carry the students on the days of clinical lectures.

In 1856, there were 75 students in attendance at the hospital, but the clinics failed to meet their own expenses. In this year Dr. Archibald B. Campbell describes the hospital as comprising "A small-pox hospital, a lunatic asylum, a children's asylum, a lying-in department, a nursery, a hospital for medical, surgical, venereal, and mania *à pótu* cases, besides the almshouse properly so-called." These departments were not under specialized supervision. In the year 1857, the entire medical visiting staff including six resident physicians resigned when Dr. James McClintock was appointed chief resident. He

was alleged to be engaged in the production of medicinal preparations, whose contents were not known and for this, among other reasons, he was frowned upon by the medical board.

On November 22, of 1858, the petition of medical students of the city to resume lectures was acceded to and in 1859, a new board was appointed by the courts. This board comprised of intelligent and liberal men entered upon a program of reform. They disposed with the office of chief resident and appointed a medical board of twelve members to act as physicians, surgeons, and obstetricians, each to visit the institution four times a week. This reorganization of the Board of Guardians removed it from the politics-ridden influence of the day and made possible its advance into the great clinical school of medicine in this country.

In 1860, the wards were opened for free clinical instruction and Doctor Agnew was appointed curator of the newly founded pathological laboratory. In 1863, the feeble-minded children were separated from the general group at Blockley and sent to the Training School at Media.

In 1874, an increase in the number of attending physicians on the surgical and obstetrical staffs was effected and the superintendent recognized as in charge of the insane department.

In 1877, the neurological department was founded which was to bring fame to such men as S. Weir Mitchell, Charles K. Mills, Francis X. Dercum, Henry Lloyd, William G. Spiller, and Charles W. Burr, due to their devoted work and study in the field of nervous and mental diseases, the greatest source of their inspiration and material being secured from the patients in the wards for nervous diseases of the Philadelphia Hospital. Departments of ophthalmology and dermatology were also instituted at this time.

From 1877 until 1884, corps of nurses from the training school of the Woman's Hospital of Philadelphia served in the institution in an efficient, enthusiastic, and faithful manner, acquiring wide experience and supplementing the haphazard method which had been in existence prior to this time at the institution, due to the use of former patients and male nurses, usually selected through political influence.

The year 1884 is memorable in that on July 28, Miss Alice Fisher, formerly superintendent of the General Hospital in Birmingham, England, and recommended by Florence Nightingale, was secured as superintendent of nurses to organize a training school at the Philadelphia General Hospital. Through the influence of citizens such as Anthony J. Drexel, George W. Childs and Richard C. McMurtrie, she was able to establish, with the help of Miss Horner whom she selected as assistant, classes for student nurses. Although she died 4 years later, the training school had been so well organized and directed that her assistant, Miss Horner, found little difficulty in carrying on the high and efficient standards which Miss Fisher had instituted. There followed in the history of the training school a succession of brilliant women who conducted the hospital along the most modern lines of nursing, until its plan and its organization have been models for other institutions which arose in later years. Miss Marian E. Smith was a member of the first graduating class in January, 1886, and later became superintendent of the hospital where she brought into accomplishment the full program of her teacher and her predecessor. Miss Smith later became superintendent of the University of Pennsylvania Hospital, where her keen knowledge of nursing and medical supervision combined to give this institution first rank among the hospitals of the country.

In 1890, the hospital was divided into four departments, medical, surgical, obstetrical, and neurological, with special wards under the care of dermatological, laryngological, ophthalmological, venereal, alcoholic, and other specialized departments which had been added as the progress of the times indicated their necessity. In 1890 the medical and surgical staffs consisted of eight members each; the neurological of four, with two ophthalmologists, two dermatologists, two laryngologists, a pathologist, and a bacteriologist. The medical board has been elected annually in December since the creation of the new Department of Health and Charities, and the appointments made by the director of the department.

Medicine throughout this country, has been profoundly influenced by the work and teachings of Sir William Osler, and it must be borne in mind that here within the walls of "Old Blockley" he performed thousands of autopsies and made his great pathological and clinical observations which made him the recognized authority in medicine, not only in his day, but to the present time. This contribution alone binds the medical profession to the Institution which made available the vast amount of material which came under Dr. Osler's direct observation and analysis.

Under the leadership of Doctor Furbush and Doctor Krusen, as directors of Public Health, the hospital has found its most modern expression. The new additions and organizations have been carried out under the superintendency of Dr. Joseph C. Doane and Dr. William Turnbull, so

that the "Old Blockley" of today is a monument of modern medical science, completely housed within new and elaborate buildings and augmented by a huge Municipal Hospital for Contagious Diseases as well as a large institution for the Insane, situated at Byberry in the suburbs of Philadelphia. The history of "Old Blockley" from 1890 to the present time is within the knowledge of most of the profession today. The tremendous influence which it has exerted upon the medical profession of America may be realized to some extent when one recalls that with the advent of this institution as an Almshouse there arose the possibility for clinical teaching of medicine with the founding of the first medical school in America.

The physicians who founded the University of Pennsylvania in 1765, were notably, John Morgan and William Shippen, Jr. Doctors Adam Kuhn and Benjamin Rush joined them to form the first teaching staff of that institution. These men all received their training in Edinburgh and returned to Philadelphia to practice. Their teachings were absorbed by the younger men who benefited by the clinical experience gained at the Almshouse, and went forth to practice according to the precepts and teachings which they had received, colored as they were by the methods of caring for the sick, then in existence, and stimulated to better things by the defects which they observed. It is not surprising that the graduates who passed through this early institution of learning and who received their medical experience in the wards of the old Almshouse should have been inspired to organize new centers of learning, so that one may trace among the founders of 29 of our large medical schools of today the names of men graduated from the University of Pennsylvania and Jefferson, and who instituted in their new schools the influences received from their student days at "Old Blockley."

The "Philadelphia Almshouse" has exerted its influence directly or indirectly on the majority of medical institutions of learning in this country. Later known as the "Better-House," and finally, by the familiar term of "Old Blockley" it stands today in the majesty of two hundred years as an historic beacon to light the path of medical progress under the formal designation of the Philadelphia General Hospital.

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2. Ibid. p. 36.
3. Ibid. pp. 31–32.
4. CROSKEY, JOHN WELCH. "Introduction." History of Blockley. Philadelphia: F. A. Davis Company, 1929, p. 11.
5. Ibid. p. 12.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

IT is rather a novel compliment to Barling, who is professor of surgery in the University of Birmingham, to be listed as co-editor of a pediatric "system" which must essentially be largely medical. Forty-six authors, who are English with the exception of one Canadian and several Americans, have collaborated in the production of *Diseases of Infancy and Childhood*.[1] The two volumes, totaling 1708 pages, are very compact in view of the fact that pediatric medicine and surgery are adequately covered. This is largely due to the fact that English medical authors seem to possess the desirable trait of omitting the tedious tables of statistics which clutter up so many American textbooks. Added to this is a fluidity of style and sufficient injection of personality to add materially to the reader's enjoyment.

Of course, there occur minor differences in the approach to certain problems as compared to ideas prevalent in America. Citing an example, Spence's attitude that subjects of intracranial birth injuries usually die or recover without sequelæ would be open to serious question in this country. Nor is Harries' blanket endorsement of Dick serum and the minimizing of the virtue of convalescent human serum in the treatment of scarlet fever acceptable to the average American pediatrician. Among his five indications for surgical intervention in acute mastoiditis Williams lists, (1) pain, fever, or tenderness persisting 48 hours after onset of discharge, (2) œdema, and (3) otorrhœa persisting 4 weeks from the start. His viewpoint seems rather radical.

Among its many virtues the work includes brilliant word pictures of various clinical entities. This applies particularly to the contagious. As might be anticipated the sections on rheumatism, tuberculosis, and heart disease are exquisitely done. Sir Humphrey Rolleston's treatment of blood dyscrasias is lucid and understandable, when one considers the confusion surrounding that topic at the present time. Surgical entities discussed at length include cleft palate, hare-lip, and orthopedic conditions. "Psychical disorders of the nervous system" is disappointing in that it would seem to retain an "organic" rather than the "functional" approach being adopted by American psychiatrists and pediatrists. The fault of overlapping discussion of the same subjects has obviously been studiously avoided except in the handling of pulmonary tuberculosis, heart disease, and nutritional disorders of infancy.

An appendix of 59 diversified radiograph plates terminates this very worth while textbook.

JAMES H. WALLACE.

FROM the observations and experience gathered together from many authorities upon the subject of gastro-enterology, Arafa[2] presents what he considers the modern methods of investigating and treating problems involved.

In the first two chapters the author gives detailed methods of accurate history taking, physical examination, and radiological technique both of a normal and a pathological stomach; also he shows the value of gastric analysis and the various means and methods of examining the gastric contents. The instruments used and their value in securing a more direct view of the stomach are discussed.

Chapters III and IV deal with chronic gastritis and peptic ulcer. Various methods of making a differential diagnosis of these conditions are discussed in full and methods of treatment are suggested including the general principles of the diet that should be correlated with the medical treatment.

The subject of intestinal disease is opened with a discussion of the clinical physiology of the intestinal tract and its relation to the stomach and its functions. The same general plan of presenting what the author considers the most valuable methods of diagnosis and treatment is carried out.

In Chapter VIII is discussed cholecystography and duodenal intubation. The technique and interpretation of the results are given special consideration. Dr. Knott has also given a discussion on the method of examining the contents of the duodenum.

Chapter IX covers a study of the pancreas, its clinical physiology and pathological lesions.

The chapter on simulation of the gastro-intestinal diseases stresses the important fact that in order to study and treat diseases of the stomach and intestines intelligently one must bear in mind the manner in which diseases of other organs of the body reflect their symptoms on the alimentary tract.

The last chapter is devoted to practical dietetics. A general discussion is given on food and the three principal classes of food—protein, carbohydrates, and fat. A brief general discussion is given to the dietotherapy in gastric and intestinal disorders.

The book is simply written, should interest the general practitioner, and, for a quick review, the student of gastro-enterology.

C. J. BARBORKA.

[1] DISEASES OF INFANCY AND CHILDHOOD. By Leonard G. Parsons, M.D., F.R.C.P., and Seymour Barling, C.M.G., F.R.C.S. Vols. i and ii. New York and London: Oxford University Press, 1933.

[2] MODERN ASPECTS OF GASTRO-ENTEROLOGY. By M. A. Arafa, M.R.C.P. (Lond.). With Foreword by Arthur F. Hurst, M.D., F.R.C.P. Baltimore: William Wood and Company, 1933.

A VERY happy combination for dealing scientifically with the subject of football injuries is had in the collaboration of two men like Stevens and Phelps[1], since the one is not only a football coach and player but also a surgeon, and the other, an orthopedic surgeon, possesses the technical skill and knowledge peculiar to that subject.

The first chapter, which deals with training and physical equipment has some very apt remarks in it. Although enthusiastic for football, the authors say: "Players who have injuries should not be allowed to participate in either scrimmage or a game. If he conceals such a fact from the trainer or coach (or doctor), he not only does harm to himself, but handicaps his team." And again when "an injury does not yield to accepted treatment within a reasonable time (under the doctor), the players may seek men not well qualified to treat their injuries, and fall victims to quacks of various sorts, and be grossly maltreated. Players should not be allowed in any case to be treated outside, without consulting the physician in charge. The only way to control football injuries is for competent men to have absolute charge of the injuries and their treatment." And again: "it is a most annoying sight to see a number of coaches or trainers yanking and hauling at a player's leg in a blind effort to pull something back into place; a something with which they are entirely unfamiliar and utterly incompetent to handle, despite the fact that reduction is usually a very simple matter in the hands of an experienced physician."

[1]THE CONTROL OF FOOTBALL INJURIES. By Marvin Allen Stevens, M.D., and Winthrop Morgan Phelps, M.D. New York: A. S. Barnes and Company, 1933.

Smoking, drinking, and sexual indulgences are advised against. Rest, plenty of sleep, conditioning exercises and physiotherapy, properly supervised, are recommended.

The bulk of the book is taken up with the different types of injuries. Motion picture films illustrate the mechanisms by which most of the injuries are produced. Anatomical and scientific descriptions are given of the parts involved, and "skills" and techniques are outlined by which injuries can be avoided. The authors lay great emphasis on the necessity of keeping the parts of the body well under control during activity, as many injuries are acquired by awkward players, or players "loafing."

In the case of given injuries, diagnostic signs and symptoms are pointed out. Repeatedly the use of the X-ray is urged when in doubt, and consultation or treatment by specialists is advised. Special treatment is then outlined for the different injuries. The book is quite up to date, the latest approved treatment for various conditions being given; as in the case of recurrent dislocations, the Nicola operation is advised and has been done with success.

Finally, several tables of statistics on football injuries and deaths and careful analysis of them are given.

The authors are not only to be congratulated upon their book, which is the first of its kind and should act as a textbook for coaches and trainers as well as for physicians interested in athletic injuries; but are also to be congratulated upon their attitude of "always keeping in mind that the individual comes first, and the athletics are purely secondary."

MARCUS H. HOBART.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

SAN FRANCISCO CANCER SURVEY; EIGHTH PRELIMINARY REPORT. By Frederick L. Hoffman, LL.D. Newark, N. J.: The Prudential Insurance Company of America, 1933.

THE GLASGOW ROYAL MATERNITY AND WOMEN'S HOSPITAL. Medical Report for the Year 1932. Prepared by D. McK. Hart, M.B., Ch.B., F.R.F.P.S.G., M.C.O.G. Glasgow: Aird & Coghill, Ltd., 1933.

THE ORIGIN OF CANCER. By J. P. Lockhart-Mummery, M.A., M.B., B.C. (Cantab.), F.R.C.S. (Eng.) London: J. & A. Churchill, 1934.

THE CLINICAL MANAGEMENT OF HORSESHOE KIDNEY; A STUDY OF HORSESHOE KIDNEY DISEASE, ITS ETIOLOGY, PATHOLOGY, SYMPTOMATOLOGY, etc. By Robert Gutierrez, A.B., M.D., F.A.C.S. With a Foreword by Dr. Edmond Papin. New York: Paul B. Hoeber Inc., 1934.

A TEXTBOOK OF THE PRACTICE OF MEDICINE. By various authors. Edited by Frederick W. Price, M.D., F.R.S. (Edin.). 4th ed. New York and London: Oxford University Press, 1933.

MONOGRAPHS OF THE BAKER INSTITUTE OF MEDICAL RESEARCH. No. 2. The Spread of Tumours in the Human Body. By Rupert A. Willis, M.D., B.S., D.Sc. London: J. & A. Churchill, 1934.

MONOGRAFIE E TRATTATI DI BIOLOGIA E DI MEDICINA. Under the direction of Prof. Carlo Foà. TRATTATO DI ROENTGEN- E DI CURIE-TERAPIA. Directed by Felice Perussia and Enzo Pugno-Vanoni. Vols. i and ii. Milano: Fratelli Treves Editori, 1934.

A TEXT-BOOK OF GYNAECOLOGY, FOR STUDENTS AND PRACTITIONERS. By James Young, D.S.O., M.D., F.R.C.S.E., F.C.O.G., 3d ed. rev. enl. New York: The Macmillan Company; London: A. & C. Black, Limited, 1933.

TREATMENT; IN GENERAL PRACTICE. By Harry Beckman, M.D. 2d rev. ed. Philadelphia and London: W. B. Saunders Company, 1934.